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[THIRD SERIES.]

ART. XIX.—*Some Determinations of the Energy of the Light from Incandescent Lamps;** by ERNEST MERRITT, M.E, Fellow in Physics at Cornell University.

[Contributions from the Physical Laboratory of Cornell University, No. IV.]

IN the numerous experiments that have been made on the efficiency, life, etc., of incandescent lamps, the light from the lamp is always measured photometrically, and is expressed in candle powers. For most purposes this method is satisfactory, for it is the luminous effect of the light that is of practical importance. It is of some scientific interest, however, to determine what proportion of the energy supplied to a lamp is given off as light, and what proportion is wasted, practically, as dark heat. Photometric methods are evidently of no use in determinations of this kind. The candle power is rather a physiological than a physical unit; it measures the effect of light waves on the eye, and not the energy of these waves. It was necessary, therefore, on beginning the investigation to be described in this paper, to find some means of separating the visible from the invisible rays, and of measuring each in units of power.

The most exact method would probably have been to form a spectrum of the light to be tested with a rock salt prism, and to measure the energy of the visible and invisible portions by

*Read before the American Association for the Advancement of Science, Cleveland, August, 1888.

means of a bolometer. The elaborate character of the experimental preparation necessary to the successful carrying out of the bolometric method was, however, such as to necessitate its rejection, and recourse was had to a modification of the method first used by Melloni.* He separated the light from the dark heat by passing the radiations to be measured through a thin layer of water, or better still through a solution of alum in water. While the dark heat is almost entirely absorbed, the light nearly all passes through. The energy of the light can then be measured by a thermopile, and that of the dark heat by the rise in temperature of the water.

I. *Calorimetric Method.*

The first experiments which I shall describe were made by Mr. S. Ryder and myself in the spring of 1886. The lamp to be tested was placed in a large glass calorimeter, and maintained at the desired degree of incandescence. The greater part of the light escaped through the glass, but the dark heat was absorbed by the water and raised its temperature. The energy of the dark heat could thus be measured. Corrections were made for radiation, and for the absorption of light by the calorimeter. The total energy supplied to the lamp being determined by electrical measurements, the difference between this total energy and the energy of the dark heat gave the energy of the visible rays.

The calorimeter was cylindrical in form, being 22^{cm} in diameter and 38^{cm} high. It held about ten liters of water, and was supported by two narrow bars of iron, which offered a quite inappreciable obstruction to radiation.

During the progress of the experiment, distilled water was allowed to flow through the calorimeter in a steady stream, entering at the bottom through the glass tube E [fig. 1], and passing out at the top through the tube F. The temperature of the water when entering and leaving was determined by means of the thermometers C and W, placed in the entrance and exit tubes of the calorimeter.

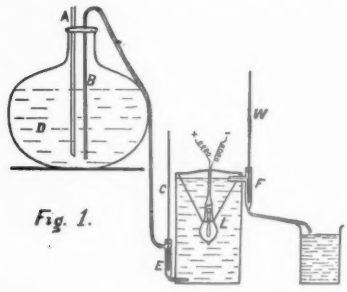


Fig. 1.

If the current in the lamp, and the rate of flow of the water, remain constant, then the difference in temperature between the water entering and that leaving

* Melloni: "La Thermochrose," Naples, 1850.

must also remain constant, and the heat absorbed by the water is measured by the product of this difference in temperature into the amount of water passing through the calorimeter.

Let t = time occupied by the experiment.
T_1 = temperature of water entering.
T_2 = " " leaving.
F = rate of flow of the water.
R = heat lost by radiation.

Then H, the heat absorbed by the water is:

$$H = [T_2 - T_1]Ft + R.$$

This method of determining the heat absorbed was adopted for several reasons. In the first place the correction for radiation was very small; we were always able to make the temperature of the air intermediate between T_1 and T_2 and of such value that the absorption of heat by the lower part of the calorimeter nearly balanced the radiation from the upper part. As it was impossible in our experiments to use a water jacket, or similar arrangement for reducing the radiation, this fact was of great importance. Then, if the ordinary form of calorimeter had been used, it would have been necessary to use a stirrer, which would have absorbed a considerable amount of light. Finally, by using this method we were enabled to take a number of readings of temperature and current instead of only one, and could continue the experiment as long as we wished.

The electrical energy supplied to the lamp was determined by measurements of current and resistance. The dynamo furnishing the current was allowed to run at its normal potential and to send a current of 10 or 15 Ampères through a dead resistance of heavy German silver wire. The lamp was connected so as to be in multiple with enough of this resistance to give the desired difference of potential. The resistance in multiple with the lamp, and the resistance of the lamp connections, were measured after the close of each experiment. The total current, and the lamp current, having been measured during the experiment, the resistance of the lamp was calculated from these data. The large tangent galvanometer in the Magnetic Observatory of Cornell University was used in measuring currents. For H the average value 0·1718 was used throughout the experiments.

The thermometers used were Baudin's "specific heat" thermometers, Nos. 10214 and 10294, graduated to 0°·02. They were read every minute by means of telescopes placed about two metres away and at the same height as the mercury in the tubes. After each experiment the two thermometers were compared to determine the difference in zero point. Curves

were drawn after each test showing the variations of T_1, T_2, and of the lamp current C. The changes in T_2 were found to be slight and to correspond almost exactly with changes in the lamp current.

In calculating the rise of temperature it was necessary to allow for the time occupied by a particle of water in passing through the calorimeter. Since the rise in temperature of each particle is the difference between its temperature when entering and its temperature when leaving, T_1 must be observed before T_2. The exact difference in time depends on the rate of flow and the capacity of the calorimeter. The correction to be applied to T_1 was usually small.

The rate of flow, F, was kept constant by an arrangement similar to the "Mariotte's bottle" used in illustrating the laws of hydrostatics. D (fig. 1) is a large carboy filled with distilled water, and closed by an air-tight stopper. Through this stopper two glass tubes A and B pass down into the water, reaching nearly to the bottom of the carboy. The tube A is open to the air at the top, while B is connected by means of a rubber tube with the entrance tube, E. The carboy being air-tight except for the tube A, the rate of flow must depend on the difference in level between the surface of the water in the calorimeter and the lower end of A. The flow will therefore remain constant until the level of the water in the carboy has fallen below the bottom of the tube A. As a matter of fact F never varied more that 0·1 per cent in an hour or more. F was measured by weighing the water discharged in a known time.

The correction for radiation was complicated by the fact that the water in the calorimeter did not come quite to the top, but left a layer of air two or three centimeters thick between the lid and the surface of the water. For this reason the radiation coefficient for the lid was less than for the sides and bottom. The two coefficients were determined as follows: On a warm day, when the water in the carboy was several degrees cooler than the air, the water was allowed to flow through the calorimeter for two hours, and readings were taken of T_1 and T_2. The rate of flow was also determined in the usual way. Since the lamp was not running, the rise in temperature must have been due to absorption of heat from the air. This rise was only about 0°·3, while the difference between the temperature of the air and the mean temperature of the calorimeter was almost 5°. Hence it was not far wrong to say that the surface temperature of the calorimeter was the same at all points, and equal to the mean temperature of the water. This experiment then gave the sum of the two coefficients R_1 and R_2. The coefficient, R_1, for the lid was then determined separately. A

thermometer was inserted through the lid of the calorimeter, (the flow being stopped) so that the bulb was just covered by the liquid. The water being about 4° warmer than the air, its gradual cooling was shown by the thermometer. Since the sides and bottom cooled more rapidly than the top, there were no convection currents, and the fall in temperature shown by the thermometer was due to the radiation from a layer of water at the top whose depth was equal to the length of the thermometer bulb. The greater part of this radiation must have been from the upper surface. Some heat escaped from the sides of the layer, but, since the sum R_1+R_2 was known, this could be allowed for, and R_1 was determined. The radiation from the cylindrical surface of the calorimeter during an actual test, depended also on the mean *surface* temperature. After each experiment, therefore, the surface temperature was measured at seven different points by means of a thermometer let down into the calorimeter and placed as close to the sides as possible. A curve was then plotted showing the distribution of surface temperature. The mean ordinate of this curve gave the mean temperature of the cylindrical surface. The temperature of the bottom was taken as equal to that of the water entering, and the temperature of the top as equal to that of the water leaving.

To test the accuracy of the whole method we made several experiments with the lamp surrounded by a copper case, which allowed the water to circulate freely and yet shut off all the light. The heat given to the water should in this case be exactly equal to the electrical energy consumed. The mean of two determinations showed the agreement between the heat energy and electrical energy to be within 0·25 per cent.

In computing the results we used Lord Rayleigh's determination of the ohm, viz:

$$1 \text{ B A unit} = 0{\cdot}98677 \text{ true ohms}$$

and Rowland's value of the mechanical equivalent of heat:

$$1 \text{ calorie} = 4{\cdot}179\ 10^7 \text{ ergs, at } 20°.$$

The correction for the absorption of light by the calorimeter was determined photometrically. Curves were found connecting candle power and potential when the lamp was in the calorimeter and when outside. From these the absorption was calculated. It was found to vary from 25 per cent to 30 per cent.

Another needed correction was due to the fact that water does not absorb quite all of the dark heat from a highly heated source. It seems, as Tyndall first pointed out,* that the penetrating power of dark heat increases as the temperature of the

* "Contributions to Molecular Physics." Tyndall, p. 264.

source rises. The correction due to this fact was determined as follows: The radiations from the lamp, after passing through the water and glass of the calorimeter, were allowed to fall on the face of a delicate thermopile, and the deflection of the galvanometer in circuit was observed. A small cell containing an opaque solution of iodine in carbon disulphide was then placed between the pile and the lamp, and the deflection again observed. The iodine solution cut off the light entirely, but allowed the dark heat to pass through. The ratio of the second deflection to the first, therefore, gave the ratio of the dark heat escaping from the calorimeter to the total radiant energy that escaped. It was found that a little less than one-third of the energy that had passed through the glass and water of the colorimeter, was dark heat. This correction was determined for each particular candle power at which the lamp was run.

The lamp used in the experiments was an Edison "108 volt," 16 C. P. lamp with a cold resistance of 255 ohms. This lamp was perfectly new when the tests began. Determinations of the energy of the light were made at seven different candle powers; the results are given in the following table:

Lamp A. Edison.

E. M. F.	W	C. P.	L	$\frac{L}{W}$	$\frac{L}{C.P.}$
74·2	34·6	0·9	0·18	0·005	0·59
91·6	56·2	4·8	0·68	·012	0·14
97·3	64·6	7·3	1·13	·017	0·15
100·3	69·3	8·9	1·62	·023	0·18
107·6	81·6	14·6	2·97	·036	0·20
109·3	84·4	16·3	4·57	·054	0·28
124·1	115·4	38·2	7·46	·065	0·19

In this table W is the total energy, in Watts; L the energy of the light, also measured in Watts; and C. P. the candle-power.

Some of these results are shown graphically in fig. 3. The curve A is found by taking as abscissæ the different values of W, and as ordinates the corresponding values of L. The vertical scale is about ten times the horizontal.

II. *Determinations made with the Thermopile.*

I returned to this subject in 1888 and continued the investigation by a somewhat different method. The calorimeter was abandoned, and for absorbing the dark heat a cell one decimeter thick containing a strong solution of alum was used. After passing through this cell the light was allowed to fall on a thermopile, and the deflection was observed. Then the

alum cell was removed and the deflection corresponding to total radiation was observed. The ratio of the two deflections gave the ratio of the light energy to the total energy. The total energy being determined by electrical measurements, the energy of the light could be calculated.

Fig. 2 shows the arrangement of the apparatus. The lamp, L, was placed close behind the screen W. This was a metallic vessel of the form shown, and was filled with water. A cylindrical opening through the center allowed part of the light from the lamp to pass through. This screen prevented any heat from the supports of the lamp from reaching the pile. Beyond this water-screen was the cell C containing the solution of alum, and beyond C the large screen S of asbestus paper. There was a small opening in this screen, directly in line with the opening in W, and covered by a movable piece of asbestus paper A. The pile P was placed with its funnel-shaped tube about 5^{cm} from A. Close to the end of the other funnel of the pile was the asbestus screen S′, which served to protect the right-hand face from sudden changes of temperature. The total distance from the lamp to the pile was about two feet.

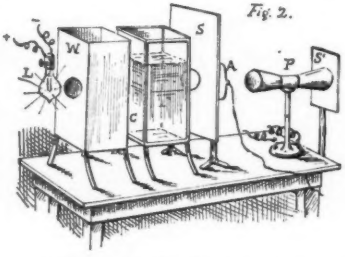


Fig. 2.

The pile contained 56 pairs with a total surface of about $2{\cdot}5$ sq cm. Wires led from it to a Thomson tripod galvanometer of about 0·3 ohms resistance. The galvanometer and scale were placed at some little distance from the pile, and the screen S was between the pile and the observer. The galvanometer was so delicate, that it was impossible to keep its zero point from drifting. As it took fully four minutes for the needle to reach its final deflection when the light was allowed to fall on the pile, and as the lamp current was not at all steady, this movement of the zero point made it difficult to obtain reliable deflections, but a peculiarity in the manner in which the needle reached its final position, simplified the matter greatly. The screen A could be suddenly drawn aside by means of a cord reaching to the observer, so as to allow the lamp to shine upon the pile. When this was done the spot of light which indicated the motion of the galvanometer needle, moved quickly to one side. But in two or three seconds it began to move more slowly, and in about five seconds stopped, moved backward a short distance, and then on again. Several of these maxima and minima could be noticed before

the final deflection was reached. The needle *always* moved in this way, no matter whether the final deflection was large or small. Using a steady gas flame as a source of heat, and taking special precautions to avoid drafts of air, I determined the ratio of this first deflection to the final deflection throughout the range of deflections used in these experiments. The ratio was constant and equal to 32·6 per cent for deflections between 20 and 100 scale divisions. For deflections less than 20 the ratio rose rapidly to 50 per cent at 1·7 divisions. The curve found by plotting this ratio, and the first deflection, resembled an equilateral hyperbola with vertical and horizontal asymptotes.

In the experiments with incandescent lamps the first deflection alone was observed, and the value of the corresponding final deflection was calculated from the curve just described. As the first maximum was reached in about five seconds the error from change of zero point was very small.

The proportionality of deflections to heating effects was shown by plotting a curve for each lamp tested, in which ordinates represented deflections and abscissæ Watts expended in the lamp. In every case this curve was very nearly a straight line passing through the origin. What slight variation there was might be accounted for by the convection from the glass of the lamp.

In the actual tests the alum cell C was first removed and the deflection corresponding to total radiation was observed. Then the cell was placed in position, and the deflection due to the light was taken. Finally a cell containing an opaque iodine solution was placed between the alum cell and the pile, and the deflection again observed. This gave the correction for dark heat passing through the alum. In each case the correction due to any difference in temperature between the pile and the apparatus was determined by taking the deflections when the lamp was turned off. The correction for light absorbed was found in the same way as when the calorimeter was used. It varied from 25 per cent to 30 per cent as before. Only about 10 per cent, however, of the radiations passing through the alum, were dark heat. For low candle powers the percentage was much less even than this.

The lamp current was measured by a Thomson ammeter, calibrated from the large tangent galvanometer. With each lamp tested the curve between current and Watts was determined once for all by measurements with the galvanometer. The energy expended in the lamp could then be calculated from its current.

The results for the four lamps tested by this method are given below. As in table A, W is the total energy expended,

measured in Watts; L is the energy of the light, also measured in Watts; and C. P. is the candle power.

Lamp B.

An Edison 16 C. P. Lamp. Resistance = 249 ohms.

E. M. F.	W.	C. P.	L.	$\frac{L}{W}$.	$\frac{L}{C.P.}$.
63·0	25·4	0·3	0·42	0·016	1·61
74·6	37·8	1·0	0·77	·021	0·79
85·4	52·5	2·5	1·96	·037	0·78
99·0	72·2	6·3	4·30	·059	0·68
116·0	102·0	15·2	7·38	·072	0·49

Lamp C.

Weston 16 C. P. Cold resistance = 402 ohms.

E. M. F.	W.	C. P.	L.	$\frac{L}{W}$.	$\frac{L}{C.P.}$.
72·0	21·6	0·4	0·46	0·021	1·27
87·4	33·5	1·5	1·10	·033	0·76
102·0	47·8	4·4	2·09	·044	0·48
117·0	66·1	10·7	3·19	·048	0·30

Lamp D.

Weston 16 C. P., 70 volt. Resistance = 152 ohms.

E. M. F.	W.	C. P.	L.	$\frac{L}{W}$.	$\frac{L}{C.P.}$.
43·0	25·8	0·5	0·53	0·021	1·06
50·7	36·0	1·6	0·97	·027	0·62
60·5	52·0	5·2	2·03	·039	0·39
67·5	65·5	11·0	3·95	·060	0·36

Lamp E.

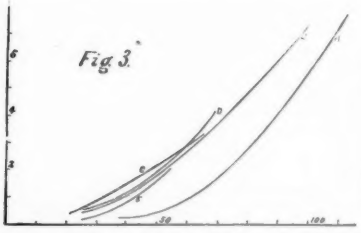
Bernstein 8 C. P. Resistance = 11·3 ohms.

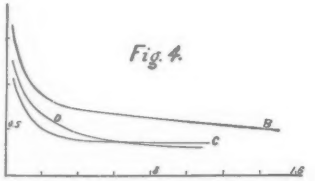
E. M. F.	W.	C. P.	L.	$\frac{L}{W}$.	$\frac{L}{C.P.}$.
12·2	25·2	0·2	0·20	0·008	1·00
13·4	30·8	0·5	0·41	·013	0·84
15·0	40·4	1·3	0·75	·018	0·57
16·4	53·2	4·1	2·03	·038	0·50

The curves of light energy, L, and total energy, W, for these four lamps are shown in fig. 3.

None of the lamps tested were of the most recent styles, all being made previous to 1886. All of the lamps, also, except lamp A, had been used a greater or less time before the tests were made. Lamps B and E especially had seen a great deal of use, and had their glass globes slightly blackened.

The curves in fig. 4 show the relation between candle power and light energy at different candle powers. Abscissæ are the candle powers at which the lamps are run, and ordinates measure the energy of the light per candle power, or, in other words, the mechanical equivalent of one candle power. The numerical values of the ordinates are given in the columns





headed $\frac{L}{C.P.}$ of the tables. It will be seen that the energy per candle power varies from 1·5 Watts at 0·5 C. P. to about 0·3 Watts at 16 C. P. In every case the *intensity* of the light, as measured by its candle power, increases more rapidly than the *energy* of the light.

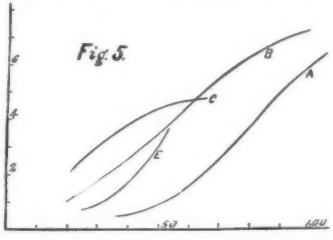
In this connection it is interesting to compare the value of the mechanical equivalent of a candle power of lamp light, found by Dr. J. Thomson some twenty years ago.* His method was similar to that used in these experiments. A cell of distilled water was used instead of an alum solution, and no correction was made for the dark heat passing through. To get absolute measurements of energy he standardized his thermopile by means of Leslie tubes. He found the energy of one candle power of light from an oil lamp to be 2·5 Watts, and for a gas flame and a standard candle the value was very nearly the same. This is considerably larger than the greatest value that I found. A part of the difference might be accounted for by the correction for dark heat passing through the water, which Dr. Thomson neglected; and the standards of light used in the two cases may have been different. It is hard to believe that the temperature of the incandescent matter in an oil flame is less than that of a lamp filament at 0·5 C. P. Recent spectrophotometric determinations by Dr. E. L. Nichols and Mr. W. S. Franklin† show that the light from a gas flame is of almost exactly the same quality as that from an incandescent lamp at 16 C. P. This would seem to indicate that the incandescent matter in a gas flame is at about the same temperature as the lamp filament.

* Julius Thomson. "Das mechanische Aequivalent des Lichtes;" Pogg. Ann. cxxv, p. 348.

† Proc. A. A. A. S., Cleveland meeting, 1888.

Some determinations of the radiation from incandescent lamps made by Capt. Abney and Col. Festing* are also of interest in this connection. The radiations from the lamp were dispersed by a prism, and the increase in the energy of each ray, as the candle power was raised, was measured by a thermopile. The curves found for different wave-lengths were approximately parabolas with vertical axes. The summation of a number of such curves should evidently give a curve similar to those found in my experiments.

There is another way of looking at the results of these experiments, which may be of some practical interest. An incandescent lamp, in fact any artificial source of illumination, may be considered as a machine for producing light. Energy in some form being supplied, the machine transforms a certain portion of this energy into luminous vibrations. Now the efficiency of any machine is the ratio of the useful work done by it to the energy expended. The efficiency of an incandescent lamp, therefore, is the ratio of the energy given off as light, to the total energy consumed. This efficiency, for the lamps tested, can be determined from the results already given by dividing the values of L by the corresponding values of W. The values of this quotient are given in the tables of results. The curves of efficiency and total energy are shown in Fig. 5. The largest value found for the efficiency was slightly over 7 per cent.



It will be noticed that this "luminous efficiency," as it might be called, does not correspond at all with the commercial efficiency of the lamp. Take for example the two Edison lamps A and B. A was new and fairly efficient, commercially, for lamps made at that time, giving 16 C. P. at about 80 Watts; B was old, and commercially very inefficient, giving 16 C. P. at something over 100 Watts. Yet the efficiency of A as a light machine was only 3·5 per cent at 16 C. P., while that of B was 7·4 per cent.! The difference must be in the quality of the light.

Dr. Thomson, whose article on this subject has already been referred to, made several determinations of the efficiency of oil and gas flames. He found that about two per cent of the radiant energy was light. This low value of the efficiency is probably not due to the low temperature of the incandescent portion of the flame, but rather to the fact that the heated

* "Relation between Electric Energy and Radiation, in Incandescent Lamps." Capt. Abney and Col. Festing. Proc. Roy. Soc., vol. xxxvii, p. 157.

gases around the flame radiate a considerable amount of heat to the pile, and yet give off no light. Dr. Thomson also found that only about 15 per cent of the heat of combustion was radiated, the remaining 85 per cent being lost by convection. The true efficiency of an oil lamp as a light-making machine is therefore only about 0·3 per cent, or one-tenth that of an incandescent lamp.

It will thus be seen, as has already been pointed out by several writers, that the incandescent lamp, though an immense improvement on gas and oil lamps, is still far from being an efficient light-making machine. Whether a light machine will ever be found whose efficiency is much greater, it is of course impossible to say, but it is a question which merits the serious attention of investigators.

Art. XX.—*Geology of Fernando de Noronha.* Part II. *Petrography;* by George H. Williams.*

What has heretofore been published in regard to the petrography of the island of Fernando de Noronha is inconsiderable, but this fact is due to the difficulty in obtaining access to the locality and the consequent rarity of material rather than to any lack of interest in the rocks themselves.

The volcanic nature of the island and the true character of its prevailing rock (phonolite) were recognized by Darwin in 1832.† The place was visited by the Challenger party in 1873, from one member of which (Willemoes-Suhm) Gümbel obtained a single specimen of the phonolite which he analyzed and examined microscopically in 1879.‡ Other specimens collected by Mr. J. Y. Buchannan, also a naturalist of the Challenger expedition in 1873, from islands of the Fernando group, although not from Fernando de Noronha itself were described by Abbé Renard in 1882.§ He figures and gives the microscopic characters of a phonolite from St. Michael's Mount (Sella á Gineta)‖ and of a nepheline basalt from Rat Island (Ilha Rapta) with an analysis of the latter. He also mentions a feldspar basalt from Platform Island (São José), and a calcareous

* For Part I, see page 145 of this volume.

† Geological Observations on Volcanic Islands, London, 1844, p. 23.

‡ Tschermak's Mineralogische und Petrographische Mittheilungen, ii, p. 188. 1879.

§ Notice sur les roches de l'ile de Fernando Noronha, Bull. d. l'Acad. roy. de Belg. (3) III, No. 4. 1882.

‖ It is probable that the phonolite specimen studied by Gümbel came from this locality, as the Challenger party appear not to have landed for scientific purposes on Fernando de Noronha itself. (Cf. Wyville Thompson's narrative, The Atlantic, II, p. 115, 1877.)

tuff containing fragments of basalt and palagonite, from both Platform and Rat Islands. At the Aberdeen meeting of the British Association in 1885, Renard made a further verbal communication on the Fernando rocks, and the complete results of his researches will be published in the Challenger reports.

The collection of Fernando rocks placed in my hands for examination numbers thirty-four specimens. They were selected as a representative suite from a much larger collection made by Professor Branner in 1876 and now deposited in the National Museum at Rio de Janeiro. Specimens from this same collection were also sent by Professor Derby to Professor Rosenbusch who mentions the following types: nephelinoid phonolite with inclusion of eleolite-syenite, nepheline basanite, nephelinite, and augitite.*

Mr. A. C. Gill, Fellow of the Johns Hopkins University, made a preliminary examination of the collection here described, identifying the following species: phonolite, nepheline-basanite, nepheline-basalt, nephelinite, basalt-glass and tuff.†

Another large collection of specimens appears to have been made by a party from the British Museum, who spent six weeks on the island of Fernando de Noronha in 1887, and from whom still further petrographical descriptions may be expected.‡

Of the thirty-four specimens in Professor Branner's collection, one (66) is travertine, and three others (18, 20 and 118), on account of their extremely altered and friable condition, were not particularly studied. In most of the remaining thirty nepheline is present, although in certain of the lightest colored and most acid rocks its presence could not be established, while in the more glassy of the basalts, if the requisite constituents for its formation exist in the base, they have not come to actual crystallization.

The specimens may be assigned to the following petrographical types:—

I. *Trachytes and Andesites.*

Hornblende trachyte	10, 121, and 129.
Hyalotrachyte	19.
Hornblende andesite	131.

II. *Phonolite.* 1, 5, 9, 35, 40, 41, 43, 51, 52, 88, 137.

* Die massigen Gesteine, 2d ed. 1887, pp. 91, 518, 624, 628, 769, 785, 802, 821.

† Petrographical notes on a rock collection from Fernando Noronha (preliminary notice.) Johns Hopkins University Circulars, VII, p. 71, No. 65. April, 1888.

‡ Rev. T. S. Lea: The island of Fernando de Noronha in 1887. Proc. Roy. Geogr. Soc., x. 424, 1888.

III. *Basalt in Rocks.*

Nepheline basanite	31, 34.
Nephelinite-dolerite	2.
Nepheline basalt	45, 72, 27.
Augitite	115.
Limburgite	14, 65.
Basalt bombs	3, 48, 58.
Basalt tuffs	54, 62.

I. *Trachyte.*

Darwin observed at the base of Fernando de Noronha beds of whitish tuff cut by dykes of trachyte,* and Professor Branner† states that these soft light-colored rocks have a very considerable development at low levels and at the base of certain of the eminences, notably Atalaia Grande and Morro Francez.

No. 121. Amphibole-Trachyte. East base of Morro Francez.—This rock is a very light greenish gray, homogeneous and comparatively compact mass, in which porphyritic crystals of sanidine and black hornblende are only rarely discernible. Under the microscope the thin section shows the same poverty in porphyritic crystals as the hand-specimen. Two or three sharply defined Carlsbad twins of sanidine and a single crystal of dark brown, intensely pleochroic hornblende are all that are present. The main mass of the rock is composed of a rather coarse-grained aggregate of feldspar crystals in two forms. The most abundant are short rectangular sections with well-defined outlines and a zonal structure, often more altered internally than at the periphery ("orthophyric feldspar" of Rosenbusch). The other feldspar is in narrow acicular or lath-shaped microliths ("trachytic feldspar" of Rosenbusch).‡ In this aggregate are further observable irregular patches of a brown globulitic glass; abundant sharp octahedrons of magnetite; minute brightly polarizing needles too small to be positively determined but doubtless pyroxene microliths with a very high extinction angle; small diamond-shaped crystals of titanite; and finally occasional minute, but very sharp dodecahedral (rarely octahedral) crystals which are transparent with a violet color and which may be perofskite, although their amount is too small in this specimen to allow of their certain identification.§ The general structure of this rock is such as is included by Rosenbusch under the Drachenfels-type. The powder of the rock is not materially attacked by strong chlorhydric acid

* Geological observations on Volcanic Islands, 1844, p. 23.

† Vid. ante, p. 9.

‡ Die massigen Gesteine, 2d ed., pp. 594–5.

§ In a letter from Professor Renard dated Jan. 30th, 1887 he announces to the writer his identification of perofskite and sodalite in the Fernando phonolite.

nor can the section be etched, except in the occasional patches of glass, by the same reagent. Mr. Gill determined by means of the Thoulet solution that all the powder of this rock, except its heaviest components (magnetite, hornblende, titanite, etc.), had a specific gravity between 2·557 and 2·455. All of these tests, as well as the general character and structure of the specimen seem to show conclusively that it contains no nepheline.

No. 129, from a dyke cutting the rock last described, possesses a somewhat anomalous character. The lack of a complete analysis, together with the altered condition of this specimen makes it difficult to define its exact position, but it probably belongs somewhere between the trachytes and andesites. A macroscopic examination is able to detect only a gray, somewhat vesicular groundmass, enclosing occasional needles of black hornblende. The vesicles are elongated in the direction of movement in the mass before its solidification and are coated with calcite and minute crystals of analcite.

The microscope discloses crystals of brown hornblende and purplish gray augite imbedded in a fine network of long, lath-shaped microliths. These latter when examined with a high power show a very weak double refraction, suggesting melilite or nepheline. Their habit, however, differs wholly from that of these minerals, while their resistance to the action of strong chlorhydric acid leaves little doubt that they are feldspar. These little microliths are often quite completely changed to calcite, and yet there is rarely visible the twinning striation characteristic of the members of the plagioclase series. A specific gravity determination yielded no satisfactory results on account of the alteration of the rock, the fineness of grain and intimate admixture of magnetite. There was a continual fall of the light-colored portions of the powder in the Thoulet solution between the limits of andesine and sanidine, but the presence of magnetite grains and zeolites prevented any conclusion being drawn from this fact. The only other original constituent observed was biotite, in very minute but sharply defined hexagonal plates. This is very abundant. The analcite of the vesicles shows between crossed Nicols its anomalous double refraction in great perfection. The percentage of silica in this rock was determined, by Mr. John White, Jr., as 50·1.

No. 10. Amphibole Trachyte, base of Atalaia Grande.—This specimen presents a pale gray lithoidal groundmass similar to the last, but the porphyritic constituents are here much more abundant. These consist of glassy idiomorphic sanidine crystals, black idiomorphic hornblende crystals, and rusty yellow spots where some mineral no longer determinable has weathered out. Under the microscope the sanidine appears quite

fresh, although it is often surrounded by a rusty border probably the result of infiltration. The hornblende is dark brown with almost complete absorption ‖ c. It is surrounded by a border of magnetite and augite grains frequently associated with sphene crystals. The yellow spots macroscopically visible mark the position of some mineral rich in iron which has now wholly disappeared. They appear as a large yellow stain in which irregular bits of some opaque iron oxide or a group of sphene crystals are occasionally clustered. The whole groundmass of the rock is also everywhere spotted with similar, but much smaller yellow stains, which have resulted from the rusting of minute magnetite crystals. The groundmass itself consists of a felt-like network of minute slender feldspar microliths, with a large amount of non-polarizing interstitial matter (colorless glass). The same small brightly polarizing needles with high extinction angle, noticed in the last specimen, are also present in this. Strong chlorhydric acid attacks this rock to a certain extent, but this is due only to the presence of the glassy base. No indication was discovered of the presence of nepheline. It was determined by Mr. Coates to contain 55·6 per cent. of SiO_2.

No. 19. Hyalotrachyte, Bahia do Sueste.—This specimen and No. 20, which was not examined microscopically, present a soft chalky mass, of a white or cream color, and contain no porphyritic crystals. Under the microscope only microliths of sanidine are visible which show in their arrangement a decided flow-structure and are imbedded in a very large proportion of a somewhat globulitic glass. The structure of this rock is typically trachytic and quite porous.

No. 131. Hornblende andesite, loose pebbles from the beach.—This contains abundant large crystals of plagioclase and a few of brown hornblende scattered through a reddish, somewhat vesicular groundmass. No other porphyritic constituents are present. The groundmass is made up of plagioclase microliths showing flow structure, and occasional minute green augite grains, imbedded in a glassy matrix which is itself apparently colorless, but rendered nearly opaque by the amount of magnetite dust present in it.

II. *Phonolite.*

The eleven specimens of typical phonolite in Professor Branner's collection all come from the eastern half of the main island and were collected either along the north shore as far west as the Peak, or on the line joining this eminence with the one on the south shore called Atalaia Grande. All are representative nephelinoid phonolites, gelatinizing readily with acid

and possessing the compact structure and somewhat oily luster characteristic of that rock. The specimens vary considerably in the relative abundance of their porphyritic crystals, range in color from dark green to pale grey, and differ in their microscopic composition and structure. No relation could, however, be discovered between these differences and the areal distribution of the rocks. The St. Michael's Mount (Sella á Gineta) phonolite described by Renard is not represented in this collection.

The distribution of the phonolite specimens (cf. map) is as follows: No. 137, N.E. corner of island, between the village and Bahia de Sto. Antonio. Professor Branner's notes say, "This is the rock most common east of the village along the north shore of the island." Nos. 1 and 35, Pedra da Conceiçao. Nos. 51, 52 and 88, Peak. Nos. 41 and 43 north of Atalaia Grande from loose blocks. Nos. 5, 9 and 40 Atalaia Grande.

The phonolites of Fernando de Noronha are remarkable for having a columnar parting more prominently developed than the separation into plates parallel to the cooling surface, so common in this rock.

With reference to their microscopic characters the specimens of phonolite at hand may be arranged as follows:

I. *Nepheline of the groundmass in distinct crystals; green bisilicate in compact stout crystalloids.*

Grain fine, little brown hornblende, no hauyne	No. 41
Grain fine, black hauyne abundant, no hornblende	9
Grain very fine, hauyne and sphene, but no hornblende	40
Grain very fine, like last without hauyne	35

II. *Nepheline of the groundmass moderately distinct; green bisilicate in more or less radiating ocellar sheaves.*

Ocellar sheaves very distinct	43
Sheaves less distinct; nepheline crystals plainer	5

III. *Nepheline of the groundmass indistinct; green bisilicate not prominent.*

Porphyritic nepheline, hauyne, sphene, flow structure	51
Porphyritic nepheline, hauyne, eutaxitic structure	88
Porphyritic nepheline, hauyne, brown hornblende, dull groundmass	137
Groundmass dull and opaque, hauyne, brown hornblende	1
Like last	52

The constituent minerals agree very closely with the diagnosis given by Professor Rosenbusch for the components of typical phonolite.

The sanidine is abundant in all specimens both as porphyritic crystals and in the groundmass. The former have a flat tabular habit parallel to their plane of symmetry, which, as a rule, lies parallel to the cleavage of the rock. Carlsbad twins are rather the rule than the exception. This mineral is younger than the hauyne but of about the same age or a little younger than the porphyritic nepheline. In some cases (No. 9) a continuation of the growth of an intratelluric crystal may be seen to have taken place during the final period of consolidation. The sanidine of the groundmass consists of lath-shaped microliths, which often exhibit in their arrangement a well marked flow structure. (No. 51.) Brown hornblende occurs only in sparsely disseminated porphyritic crystals; never in the groundmass. It is not present in all the thin sections, but this may be accidental as the hand specimens show no marked difference in this respect. Is is always surrounded by the magnetite corrosion-rim showing that it must have been wholly a product of intratelluric crystallization. Within this rim sphene is of frequent occurrence. Around the outside of the magnetite rim is a fringe of minute crystals of green pyroxene (ægirine). The hornblende is, in some cases at least, younger than the hauyne. Its pleochroism is as usual, but particularly strong.

Hauyne is abundant in many of the specimens. Its well defined crystal outline shows it to belong to the earliest secretions of the magma, as does also its inclusion in all the other constituents. It is in every instance colorless but filled with its characteristic opaque inclusions which in one section (No. 9) are so numerous as to make the mineral appear nearly black. Alteration to zeolites and to calcite are common; the latter being the ground for referring the mineral to hauyne rather than to nosean.

Nepheline is very frequent in porphyritic crystals which often possess a diameter of a millimeter or more. In this form it belongs to the oldest crystallizations of the magma. As a constituent of the groundmass it is sometimes very distinct in short stout crystals showing well defined hexagonal or rectangular outlines. In other cases it is poorly individualized and indistinct. The green bisilicate constituent of the Fernando phonolites is without doubt an alkaline pyroxene (ægirine), although its optical properties are so like those of hornblende that in minute individuals devoid of crystalline form, it is not strange that it should be confused with this mineral. As a porphyritic constituent it is rare and unimportant, the crystals being always comparatively small. These generally exhibit a zonal structure, with a gray or violet-colored center and a weak pleochroism. In the groundmass the ægirine occurs either as short stout crystalloids or in more or less radi-

ating "ocellar" tufts crowded with small nepheline crystals. Its lack of well developed form indicates that it was a late product of crystallization. The late Prof. C. E. Wright determined the inclination of the axis of greatest elasticity (a) to the vertical axis ($\dot{c}$) as between 7°·42′ and 16°; double refraction negative. Among the more compact crystalloids in the groundmass of No. 41 a few cross-sections were found which showed the prismatic development. These sections were hexagonal bounded by (110) and (100), while (010) is wanting. The pleochroism, which is often quite strong, is: $\bar{b}$ (b) green; $\dot{c}$ (a nearly) green; $\dot{a}$ (c) yellow; absorption. a> b>> c. All of these determinations agree closely with those given by Rosenbusch.*

The other minerals observed were sphene, magnetite and very sparingly apatite, all of which present their character usual in the phonolites. Noticeable for the sphene is its frequent occurrence in the black corrosion rims around the hornblende.

A point of considerable interest with regard to the Fernando phonolites is the possible occurrence in them of inclusions of eleolite-syenite as mentioned by Prof. Rosenbusch.† The material in hand is not however sufficient to definitely decide this question. In a communication from Prof. Orville Derby of Rio de Janeiro, in whose hands the entire collection made by Professor Brauner formerly was and who still has charge of the greater part of it, he says that in this large amount of material only a single specimen showed any sign of such an inclusion. This was a pale gray and rather coarse grained phonolite from the Peak (No. 50) which contained a sharply defined inclusion, apparently of a typical eleolite-syenite about 3^{cm} square. Of this inclusion and a portion of the surrounding phonolite one fragment was sent by Prof. Derby to Prof. Rosenbusch and another to myself. Prof. Derby has also kindly furnished me with a photograph of this specimen. If the inclusion is really an eleolite-syenite it belongs to an exceptionally porphyritic type, inasmuch as more than one-half of its small area (3×3^{cm}) is occupied by a single crystal of a blue iridescent orthoclase ($2\times1\frac{1}{2}^{cm}$). Both Profs. Derby and Branner agree that inclusions of this sort must be of rare occurrence in the Fernando phonolites.‡ and in no way comparable to those so abundant in the tinguaites of the Rio de Janeiro neighborhood. Prof. Derby is inclined to regard this inclusion as an early and intratelluric secretion of the phonolite magma. This view§ may derive some support from the fact

* Die massigen Gesteine, 2d ed., p. 616.

† Die massigen Gesteine, 2d ed., pp. 91, 628 and 821.

‡ Quart. Jour. Geol. Soc., xliii. p. 459, 1887.

§ Opinion expressed in a letter to the writer (cf. reference just cited and Neues Jahrbuch für Min., etc., 1887, II, p. 258.)

that another phonolite specimen of this collection (No. 5) does undoubtedly contain such coarse-grained secretions composed of large crystals of nepheline and sanidine. The appearance of these is however undeniably different from that of the apparent inclusion; and, in the absence of more abundant material, the writer would refrain from expressing a decided opinion.

III. *Basaltic Rocks.*

No. 31. Nepheline-basanite, São José Island.—This is a very compact black rock in which minute crystals of olivine and augite are macroscopically visible. Under the microscope these two constituents are seen to be present in abundant well-formed crystals possessing their usual characters. The ground-mass in which they are imbedded is a fine holocrystalline aggregate of augite and plagioclase microliths and magnetite grains. Some interstitial nepheline is also present, but this is of so small amount as to ally this rock to the feldspar basalts.

No. 34 is a fragment of a coarsely granular inclusion or secretion in the last described specimen. It is composed of perfectly fresh olivine and enstatite with hardly a trace of any other mineral, and is analogous to the so-called "olivine bombs," common in many basaltic rocks but whose origin is still a matter of discussion.

No. 2. Nephelinite-dolerite.—A dark gray, coarse grained rock collected in the N.E. part of the main island, but nowhere found *in situ*. Long black crystals of augite and small grains of olivine are macroscopically visible. The microscopic character of this rock agrees very exactly with Rosenbusch's description of the doleritic type of nephelinite;* and, in spite of its comparatively large amount of olivine, it is here assigned to this class on account of its close resemblance to the classic occurrences at Meiches and Löbau.

The structure of this rock is holocrystalline and granular (*hypidiomorph-körnig* in the sense of Rosenbusch†) like that of a plutonic mass. Its most prominent constituent is augite, whose jet black crystals are often a centimeter or more in length and impart to the hand-specimen a porphyritic appearance. Under the microscope these crystals have a brownish red color, a decided pleochroism and a distinct zonal structure. The colors of the different rays are c and b reddish brown; a greenish yellow; absorption $c > b \gg a$. The outer zones are invariably more intensely colored (i. e. richer in ferric iron) than the inner and are hence more pleochroic. The hour-glass structure is also frequent as a form of zone growth. The ex-

* Die massigen Gesteine, 2d ed., p. 791.
† Ib., p. 11.

tinction angle is very high and twinning lamellæ intercalated parallel to the orthopinacoid (011) of common occurrence. To all appearances this augite is identical with that of the Kaiserstuhl basalts which has been studied by Knop and found by him to be titaniferous.*

The olivine of this rock is in some slides quite abundant; in others less so. It is very fresh and of a pale yellow color. It occurs commonly in small grains, but more rarely in sharp crystals.

The colorless component is for the most part nepheline in large crystals, easily recognized by negative uniaxial character, its parallel extinction, lack of cleavage and the ease with which it is attacked by acids. Its specific gravity is from 2·61 to 2·59.

An unstriated feldspar, probably sanidine, is present in small quantity,† and also occasionally particles of a striated feld-spar.

Sodalite in irregular patches is present in almost every section, its isotropic substance being penetrated in every direction by brightly polarizing needles of some zeolite which has resulted from its alteration.

Apatite is abundant in its characteristic forms. The iron ore is octahedral—probably a titaniferous magnetite. A small amount of the peculiar copper-colored and but slightly pleochroic mica, so common in nepheline rocks, is also present.

Nepheline-basalt is represented by three specimens in Prof. Branner's collection. One of these (No. 45) from Morro Francez agrees almost exactly with the figure and description given by Renard of a similar rock from Rat Island‡ (Ilha Rapta.) Its only porphyritic constituents is olivine in sharp crystals or irregular grains. These are surrounded by a yellow border of iron hydroxide and more or less opaque iron oxide resulting from decomposition, and appear in the compact black hand specimen as rusty yellow spots. The interior of these olivines is however shown by the microscope to be quite fresh and colorless. The groundmass is a fine aggregate of idiomorphic augite crystals, octahedrons of magnetite and nepheline, without any unindividualized base.

No. 72, from Ilha Rapta, differs from the last described specimen in having the porphyritic olivines nearly devoid of the yellow border and in possessing a slightly coarser groundmass. Within the latter may also be seen occasional flakes of a brown mica and transparent octahedral crystals which are without doubt perofskite.

* Zeitschrift für Krystallographie, x, p. 58, 1885.

† Knop has shown that a barium orthoclase is present in the closely allied nephelinite from Meiches in the Vogelsgebirge. Neues Jahrbuch für Min., etc., 1865, p. 687.

‡ Bull. d. Acad. roy. de Belge (3), III, No. 4, 1882.

No. 27 from a point on the south side of Fernando agrees closely with the last specimen except that it contains no perofskite.

No. 65 from Portão, at the west end of Fernando is a typical limburgite. In the hand-specimen it is of a dark gray color and filled with vesicular cavities of all sizes which are either coated or completely filled with zeolites. Small rusty yellow spots indicate the position of abundant olivine crystals which are the only constituent macroscopically visible. Under the microscope well-formed olivines surrounded by a yellow border are seen imbedded in a groundmass of augite microliths, magnetite octahedra and a colorless glass. Thus the rock is a limburgite of the second class in the sense of Bücking, which, as we might expect from the present association, is more nearly allied to the nepheline, than to the feldspar basalts.

No. 14, from Atalaia Grande, may also be classed as a limburgite, although from its poverty of olivine it is closely related to the augitites. The hand-specimen of this rock presents a striking contrast to the last, it being compact and black like the nepheline-basalts. Small, sharply-formed augite crystals and a few olivines are the only components visible. Under the microscope this specimen is seen to differ greatly from all the others. The olivines are few but very fresh. The augites are distinguished by their pronounced zonal structure, their interior being of a brilliant green and pleochroic, while the outer zone is reddish gray. Their extinction is very high. Smaller crystals of brown basaltic hornblende are also abundant. The groundmass consists of a brown glass somewhat devitrified with globulitic dust and occasional arborescent growth forms. This contains augite microliths, magnetite in octahedra and occasional crystals of blue hauyne. As a secondary product analcite occurs, either after the hauyne or in minute cavities.

No. 115, from Morro Francez, is a more typical augitite in being wholly free from olivine, although it approaches the nephelinites in containing nepheline, mostly in the form of porphyritic crystals. The hand-specimen shows abundant black porphyritic crystals which are in part hornblende and in part augite. The groundmass is mostly composed of a colorless glass containing augite microliths and magnetite. A little nepheline is also present in it. This mineral is, however, more abundantly present in crystals or grains of medium size imbedded in the groundmass.

Three specimens, No. 48 from Morro Francez, No. 3 from the S.W., and No. 58 from the W. corner (Japato) of Fernando, represent very scoriaceous ejected fragments (volcanic bombs) of basaltic rocks. The first is a mottled black and red

vesicular glass containing abundant porphyritic olivines externally altered and sometimes completely changed to iron hydroxide. Small yellow augite crystals are also present. The second of these specimens (No. 3) is a porous black and almost opaque glass including sharp olivine crystals. Lath-shaped forms resembling feldspar microliths also occur here, but they are now wholly replaced by some isotropic substance. No. 58 is a pumiceous fragment of a reddish gray color. Under the microscope it is seen to be composed of a colorless glass filled with minute yellow augite crystals and iron oxide globulites. In this matrix are abundant olivine crystals, now however almost wholly replaced by iron hydroxide.

Basalt Tuffs—two specimens from the western end of the island of Fernando are composed of fragments of glassy basalts cemented by zeolites. No. 54 is of a brownish color speckled with white (zeolite) and shows its fragmental character very distinctly when examined with a lens. The microscope discloses angular or rounded fragments of a reddish or yellow glass. These are of various sizes and are very vesicular, containing altered olivine crystals, lath-shaped microliths and opaque octahedrons. In external aspect this specimen resembles palagonite but it is not wholly soluble in acids and contains too many crystalline components to be properly classed under this head.*

No. 62, collected near the last, is a rock of similar character, but of less pronounced fragmental appearance. It is of a brick-red color, compact in structure and also filled with zeolitic minerals. Under the microscope it is seen to possess a character quite like the one last described, except that the glass is a deeper red and more opaque.

Petrographical Laboratory, Johns Hopkins University, Dec., 1888.

Art. XXI.—*On the Ophiolite of Thurman, Warren Co., N. Y., with remarks on the Eozoon Canadense;* by George P. Merrill.

The Warren County Ophiolite or Verdantique Marble as seen in the limited amount put upon the market, consists in its typical development of an even granular admixture of white calcite and pale yellowish green serpentine in about equal proportions. The uniformity of texture is, however, often interrupted by large irregular blotches of deep lustrous green serpentine which, as shown in a large block in the National

* Renard mentions grains of palagonite in a fragmental rock collected by Buchanan on Rat Island, loc. cit., p. 11.

Museum collections, sometimes carry a white nucleus. The presence of this nucleal material, which may frequently be observed passing by imperceptible gradations into the green serpentinous material, suggested at once that here, too, the serpentine is a metasomatic product, as the writer has shown* is the case with that of Montville, New Jersey. Thin sections of the rock under the microscope confirm this suggestion. The white nucleal mineral is seen to be an aggregate of small monoclinic pyroxenes, quite colorless in the thin sections, without pleochroism, but polarizing brilliantly and giving extinctions on clinopinacoidal sections as high as 41°. Irregular canals of serpentinous matter cut through these aggregates following cleavage and fracture lines, and all stages of alteration can, as in the Montville stone, often be observed in a single section. In the more even-textured portions of the rocks the serpentine appears as rounded or oval granules with small enclosures of secondary calcite imbedded in the large original plates of the same material. Here, too, all stages of alteration are readily detected, some of the pyroxene granules being traversed by but a few wavy threads of the serpentinous matter, while in others not a trace of the original mineral longer remains. Were it not for these fresh remaining portions one would hesitate to pronounce them pyroxenic derivatives, since they in no case show crystal outlines, but are mere oval blebs or granules imbedded like shot in the white calcite in a manner quite similar to that of the chondrodite grains in the white limestone from Amity, Orange County, in the same state. The granules are not in all cases isolated but sometimes occur in groups, or connected by canals of serpentinous matter in a manner strikingly suggestive of the detached sections and groups of Eozoon chamberlets as figured by Dr. Dawson on pages 24 and 28 of his late paper.† Indeed I can but feel, since reading his resumè that, even at this late day, this serpentinization of pyroxene is destined to throw some light on the Eozoon problem. This idea is supported by the fact that the fragmental Eozoon has been reported from these same formations at Warren County, further by Dr. Dawson's statement that eozoonal masses often occur as "rounded or dome-shaped masses that seem to have grown on ridges or protuberances, now usually represented by nuclei of pyroxene."‡ While from the study of so limited an amount of the Warren County stone it may not be advisable to assert that the remarkably regular structures figured by Dr. Dawson are due wholly to alteration in situ of

* Proc. U. S. Nat. Mus., vol. xi. 1888, p. 105.

† Specimens of Eozoon Canadense and their Geological and other relations. Peter Redpath Museum. Notes on Specimens, Sept. 1888.

‡ Op-cit., p. 29.

pyroxene granules, I can but suggest that we have in this alteration the source of the serpentinous material and that the "mineral pyroxene of the white or colorless variety . . occurring often in the lower layers and filling some of the canals" of the Eozoon, is but the residual mineral which has escaped alteration. Further, that the structureless nodules of serpentine found in the eozoonal rocks, and to which often patches of Eozoon are attached or imbedded, are but patches in which the alteration is complete and the pyroxenic nucleus quite obliterated. Dr. Dawson, although recognizing the frequent accompaniment of a white pyroxene with the eozoonal structure, in no case mentions appearances indicating that the serpentine is an alteration product, but seems rather to regard it as an original injection,* following in this respect the well known teachings of Dr. Hunt.† Those conversant with the literature of the subject may recall that Messrs. King and Rowney‡ recognized also the presence of pyroxenes in these limestones and in insisting upon the inorganic nature of the eozoon, compared its structural forms to those assumed by chondrodite, coccolite, etc. in the limestones of New York, New Jersey and other localities. These authorities seem however to have regarded the serpentine as true "replacement pseudomorphs" after these minerals rather than alteration or metasomatic products.

In conclusion: The serpentine in the Warren County Ophiolite, Ophicalcite or Verdantique as it has been variously called is an alteration or metasomatic product after a mineral of the pyroxene group. The original rock would appear to have been simply a pyroxenic limestone, the pyroxene occurring either in scattering granules or in granular aggregates of considerable size. An examination of the Essex County Ophiolite reveals a somewhat similar, though more complicated condition of affairs. A portion of the serpentine here is also derived from a pyroxene, but another, and in cases a very large portion is apparently after a mineral which I have not as yet found sufficiently unchanged to be able to identify. The rock is as yet insufficiently studied, and must be made the subject of another paper. I am indebted to Mr. George F. Kunz for the Warren County material.

National Museum, Dec. 18, 1888.

* Op-cit., p. 16–22 et als.

† Quart. Jour. Geol. Soc. of London, vol. xxi, p. 67, Chem. and Geol. Essays, etc.

‡ Quart. Jour. Geol. Soc. of London, vol. xxv, p. 115: also Proc. Royal Irish Academy, vol. x, Part IV, 1870, p. 506.

ART. XXII.—*On the Origin of the deep troughs of the Oceanic depression: Are any of Volcanic origin?* by JAMES D. DANA, with a bathymetric map, Plate VII.

THE consideration of the question with regard to the origin of the ocean's deep troughs requires, as the first step, a general review of oceanic topography; for according to recent bathymetric investigations, the deep troughs are part of the system of topography, and its grander part. We need, for this purpose, an accurate map of the depths and heights through all the great area. Such a map will ultimately be made through the combined services of the Hydrographic Departments of the civilized nations. At the present time the lines of soundings over the oceans, especially over the Pacific and Indian, are few, and only some general conclusions are attainable. It is to be noticed that the system of features of the oceanic area are involved in the more general terrestrial system; but since the former comprises nearly three-fourths of the surface of the sphere, it is not a subordinate part in that system.

With reference to this discussion of the subject I have prepared the accompanying bathymetric map.

I. THE BATHYMETRIC MAP, AND THE GENERAL FEATURES OF THE OCEANIC DEPRESSION DISPLAYED BY IT.

1. *The Map.*—In the preparation of the bathymetric map I have used the recent charts of the Hydrographic Departments of the United States and Great Britain,* which contain all depths to date, and the lists of new soundings published in German and other geographical Journals. In order that the facts on which the bathymetric lines are based may be before the reader a large part of the depths are given, but in an abbreviated form, 100 fathoms being made the unit: 25 signifying 2500 fathoms or nearly (between 2460 and 2550); 2·3, about 230 fathoms, ·4, about 40 fathoms. Only for some deep points is the depth given in full. The addition of a plus sign (+) signifies no bottom reached by the sounding.†

* I am indebted to the Hydrographic Departments of Great Britain as well as the United States for copies of these charts.

† On the map the bathymetric lines for 1000, 2000, 3000 and 4000 fathoms, besides being distinguished in the usual way by number of dots, have been made to differ in breadth of line, the deeper being made quite heavy in order to exhibit plainly the positions of the areas without the use of colors. The line for 100 fathoms is, as usual, a simple dotted line. As the bathymetric map herewith

In the plotting of oceanic bathymetric lines from the few lines of soundings that have been made, the doubts which constantly rise have to be settled largely by a reference to the general features of the ocean, and here wide differences in judgment may exist in the use of the same facts; but through the depths stated on the map, the reader has the means of judging for himself. In the case of an island the lines about it may often have their courses determined by those of adjoining groups, or by its own trend; but in very many cases new soundings are needed for a satisfactory conclusion.

Some divergences on the map from other published bathymetric maps require a word of explanation. The northern half of the North Pacific is made, on other deep-sea maps, part of a great 3000-fathom area (between 3000 and 4000) stretching from the long and deep trough near Japan far enough eastward to include the soundings of 3000 fathoms and over in mid-ocean along the 35th parallel. It has seemed more reasonable, in view of present knowledge from soundings, to confine the deep-sea area off Japan to the border-region of the ocean, near the Kurile and Aleutian islands, and leave the area in mid-ocean to be enlarged as more soundings shall be obtained. Again in the South Pacific, west of Patagonia, the area of relatively shallow soundings (under 2000 fathoms) extending out from the coast, is on other maps bent southward at its outer western limit so as to include the area of similar soundings on the parallel of 40° and 50°, between 112° and 122° W. The prevailing trends of the ocean are opposed to such a bend, and more soundings are thought to be necessary before adopting it.

It may be added here that in the Antartic Atlantic, about the parallel of 66½° S. and the meridian of 13½° W., a large area of 3000 and 4000 fathoms has been located. It was based, as I have learned from the Hydrographic Department of the British Admiralty, on a sounding in 1842 by Capt. Ross, R. N., in which the lead ran out 4000 fathoms without finding bottom. The sounding was, therefore, made before the means

published is necessarily small, and none of the ordinary maps of the oceans give either deep-sea soundings or a correct idea of the trends of the oceanic ranges of islands, I state here that the charts of the U. S. Hydrographic Department for the Atlantic, Pacific, Indian and Arctic oceans may be purchased of dealers in charts in the larger sea-board cities for 50 cents a sheet and less according to size. (There are several large charts to each ocean). One of the firms selling them in New York City is that of T. S. & J. D. Negus, 140 Water st. The British Admiralty have published a map of the Pacific with its soundings on a single sheet, and for the Atlantic and Indian oceans with part of the Pacific, besides charts of the Antarctic and Arctic seas. The occasional bulletins from the Hydrographic Department and Petermann's Mittheilungen contain nearly all the new data issued for the perfecting of such a chart.

available were "sufficient to ensure the accuracy of such deep casts."*

2. *The Feature-lines of the oceanic and bordering lands.*—The courses of island-ranges and coast-lines have a bearing on the question relating to the courses of the deep-sea troughs, and, therefore, by way of introduction, they are here briefly reviewed.† The system of trends in feature-lines takes new significance from a bathymetric map, for the courses are no longer mere trends of islands or emerged mountain peaks; they are the trends of the great mountain ranges themselves; and, in the Pacific, these mountain courses are those of half a hemisphere. Some of the deductions from such a map are briefly as follows:

(1). Over the Pacific area there are *no* prominent north-and-south, or meridional, courses in its ranges, and none over the Atlantic, except the axial range of relatively shallow water in the South Atlantic. And, to this statement it may pertinently be added that there are none in the great ranges of Asia and Europe, excepting the Urals; none in North America; none in South America, excepting a part of those on its west side.

(2). The ranges in the Pacific ocean have a mean trend of not far from northwest-by-west, which is the course very nearly of the longer diameter of the ocean. One *tranverse* range crosses the middle South Pacific—the New Zealand—commencing to the south in New Zealand and the islands south of it, with the course N. 35° E., and continuing through the Kermadec Islands and the Tonga group, the latter trending about N. 22° E., and this is the nearest to north and south in the ocean, except toward its western border.

(3). The oceanic ranges are rarely straight, but instead, change gradually in trend through a large curve or a series of curves. For example, the chain of the central Pacific becomes to the westward, north-northwest; and the Aleutian range and others off the Asiatic coast, make a series of consecutive curves. Curves are the rule rather than the exception. Moreover, the intersections of crossing ranges, curved or not, are in general nearly rectangular.

(4). Approximate parallelisms exist between the distant ranges or feature-lines; as (1) between the trend of the New

* The communication received from the Admiralty Office adds that "Some of Ross's soundings up to 2660 fathoms have been proved correct, and hence the sounding in 68° S., referred to, has been retained on our charts until disproved." "Another sounding obtained by Ross in the Atlantic has had strong doubts thrown upon it by a sounding of 3000 fathoms obtained not very far from its position." See the accompanying map, near latitude 14° S.

† This subject of the system in the earth's feature-lines is presented at length, with a map, in my Expedition Geological report, pp. 11–23 and 414–424; and also more briefly in this Journal, II, ii, 381, 1846.

Zealand range and that of the east coast of North America; and also that of South America (which is continued across the ocean to Scandinavia); also (2) between the trend of the foot of the New Zealand boot with the Louisiade group and New Guinea farther west, and the mean trend of the islands of the central Pacific both south and north of the equator, and also that of the north shore of South America. These are a few examples out of many to be observed on the map.

(5). The relatively shallow-water area which stretches across the North Atlantic from Scandinavia to Greenland—the Scandinavian plateau, as it may well be called—is continued from these high latitude seas southwestward, in the direction of the axis of the North Atlantic (or parallel nearly to the coast of eastern North America and the opposite coast of Africa), and becomes the "Dolphin shoal."

It may be a correlate fact in the earth's system of features that a Patagonian plateau stretches out from the Patagonia coast, or from high southern latitudes, in the direction of the longer axis of the Pacific, and embraces the Paumotu and other archipelagos beyond.*

The above review of the Earth's physiognomy, if accompanied by a survey of the map, may suffice for the main purpose here in view: to illustrate the general truths—that system in the feature-lines is a fact; that the system is world-wide in its scope; and—since these feature-lines have been successively developed with the progress of geological history—that the system had its foundation in the beginning of the earth's genesis and was developed to full completion with its growth.

2. Facts Bearing on the Origin of the Deep-sea Troughs.

In treating of this subject, the facts from the vicinity of volcanic lands that favor a volcanic origin are *first* mentioned;

* As parallelisms may have importance that is not now apparent, I draw attention to one between the Mediterranean Sea that divides Europe from Africa, and the West India (or West Mediterranean) sea that divides North from South America. Both have an *eastern*, *middle* and *western* deep basin. Their depths (see map) in the East Mediterranean, are 2170, 2040 and 1585 fathoms; in the West Mediterranean (the three being the Caribbean, the West Caribbean or Cuban, and the Gulf of Mexico), 2804, 3428 and 2080 fathoms. Further, in each Mediterranean Sea, a shallow-water plateau extends from a prominent point on the south side, northward, to islands between the eastern and middle of the deep basins; one from the northeast angle of Tunis to Sicily, the other from the northeast angle of Honduras to Jamaica and Haiti, the two about the same in range of depth of water. And this last parallelism has its parallels through geological history, even to the Quaternary, when the great Mammals made migrations to the islands in each *from the continent to the South.*

secondly, those from similar regions that are not favorable to such an origin; *thirdly*, facts from other regions bearing on the question.

A. *Facts apparently favoring a volcanic origin.*

1. The Pacific soundings have made known the existence of two deep-sea depressions, if not a continuous trough, *within forty miles of the Hawaiian Islands;* one situated to the northeast of Oahu, or, north of Molokai, with a depth of 3023 fathoms, or 18,069 feet, and the other east of the east point of Hawaii, 2875 fathoms, or within 750 feet of 18,000 feet. Again, 450 miles northeast of Oahu, there is a trough in the ocean's bottom, over 800 miles long, which runs nearly parallel with the group and has a depth of 3000 to 3540 fathoms; and, as far south, another similar trough of probably greater length has afforded soundings of 3000 to 3100 fathoms. The depths about the more western part of the Hawaiian chain of islands have not yet been ascertained, and hence the limits of the deep areas are not known. Such depths, so close to a line of great volcanic mountains, the loftiest of the mountains not yet extinct, appear as if they might have resulted from a subsidence consequent on the volcanic action.

The subsidence might have taken place (1) either from underminings:—which the amount of matter thrown out and now constituting the mountain chain, with its peaks of 20,000 to 30,000 feet above the sea-bottom, shows may be large; or (2) from the gravitational pressure in the earth's crust, about a volcanic region which speculation makes a source of the ascensive force and of the upward rising of the lavas,—the subsiding crust following down the liquid surface beneath. In either case the mass of ejected material might be a measure more or less perfectly of the maximum amount of subsidence.

2. In the western part of the North Pacific, at the south end of the volcanic group of the Ladrones off the largest island of the group, Guam, the Challenger found a depth of 4475 fathoms, one of the two deepest spots yet known in the Pacific. The situation with reference to the group is like that off the east end of the Hawaiian group.

3. East of Japan and the Kuriles, a region of ranges of volcanoes, there is the longest and deepest trough of the ocean, the length 1800 miles, the depths 4000 to 4650 fathoms; and farther northeast, south of one of the Aleutian islands, a depth of 4000 fathoms occurs again; and depths of 3100 to 3664 fathoms also still farther east. It is probable that the 4000-line trough continues from the Kurile to this deep spot off the Aleutian volcanic range; and if so, the length of the trough

is over 2500 miles. The map is made to suggest its extension still farther eastward; but among the very few soundings made, none below 3664 fathoms have yet been obtained off the more eastern Aleutians.

Other similar facts may be found on the map; and still others may exist which are not now manifest owing to the sinking of oceanic areas and islands. But no cases can be pointed to which are more decisively in favor of volcanic origin.

B. *Facts from the vicinity of volcanic regions apparently not referable to a volcanic origin.*

1. The ocean off the western border of North and South America affords striking examples of the absence of deep troughs from the vicinity of regions eminently volcanic. The South American volcanoes are many and lofty; and still the ocean adjoining is mostly between 2000 and 2700 fathoms in depth: and just south of Valparaiso, it shallows to 1325 fathoms. The only exception yet observed is that of a short trough of 3000 to 3368 fathoms close by the Peruvian shore. It may, however, prove to be a long trough, although certainly stopping short of Valparaiso. The waters, however, of the Pacific border of America deepen abruptly compared with those of the Atlantic border; and the significance of this fact deserves consideration.

The facts off Central America are more remarkable than those off the coast to the south. The volcanoes are quite near to the Pacific coast, and still the depths are between 1500 and 2500 fathoms.

The condition is the same off the west coast of North America. Of the two areas of 3000 and over, nearest to the east coast of the North Pacific, one is 600 miles distant in the latitude of San Francisco, and the other is within ten degrees of the equator and twenty degrees of the coast; both too far away to be a consequence of volcanic action in California, Mexico or Central America.

In the North Atlantic the European side has its volcanoes and has had them since the Silurian era, and yet the non-volcanic North American side of the ocean has far the larger areas of deep water and much greater mean depth. The Azores or Western Islands, which are all volcanic, have depths around them of only 1000 to 2000 fathoms and no local troughs. Iceland, the land of Hecla, is in still shallower waters, with no evidence of local depressions off its shores. The Canaries are volcanic, but no deep trough is near them.

C. *Facts from regions not volcanic which are unfavorable to the idea of a volcanic origin.*

1. In the North Pacific, near its center, the area of 3000 or more fathoms about 35° N.; the two similar but smaller areas toward its eastern border; the areas north of the Carolines in the western part of the ocean; the broad equatorial area about the Phœnix Group; the area in the South Pacific in 170° W., east of Chatham Island, and another just south of Australia, are all so situated that no reason is apparent for referring them to a volcanic origin. Some of the areas are in the coral-island latitudes, and the supposed volcanic basis of coral-islands makes a volcanic origin possible, but their probable size and position appears to favor the idea of origin through some more fundamental cause. The area in the South Pacific, east of Chatham Island, is 450 miles distant from the land. The border of southern Australia, abreast of the deep-sea trough, has no known volcano.

2. *In the Atlantic, away from the West Indies*.—The 3000-fathom areas of the North and South Atlantic, that is, the three in the North Atlantic, the two in the South Atlantic, and the two equatorial, one near the coast of Guinea and the other near that of South America, occupy positions that suggest no relation to volcanic conditions. The Cape Verdes, north of the equator, are partly encircled by one of the deep areas, somewhat like the eastern end of the Hawaiian group; but this bathymetric area appears to be too large to owe its origin directly to volcanic work in the group. The coast of Guinea near the 3000-fathom area has nothing volcanic about it, and the opposite coast of South America, near another, is free from volcanoes.

The only facts in the Atlantic that suggest a volcanic origin are the depression of 2445 fathoms within 40 miles of the west side of the volcanic Cape Verde Archipelago, and that of 2060 fathoms within 20 miles of Ascension Island; and a connection is possible.

3. *In and near the West Indies*.—The most remarkable of the depths of the Atlantic area are situated in and near the region of the West Indies, as is well illustrated and discussed by Mr. Alexander Agassiz in his instructive work on the "Three Cruises of the Blake." The deepest trough of the ocean, 4561 fathoms, occurs within seventy miles of Porto Rico; and yet this island has no great volcanic mountain, though having basaltic rocks. By the north side of the Bahama belt of coral reefs and islands, for 600 miles, as Mr. Agassiz well illustrates, the depth becomes 2700 to 3000 fathoms within twenty miles of the coast-line, and at one point 2990 within twelve miles, a pitch-down of 1 : 3·5; and nothing suggests a volcanic cause for

the abrupt descent. Cuba and Hayti are not volcanic, and look as if they were an extension of Florida, so that no grounds exist for assuming that the Bahamas rest on volcanic summits.

One of the strangest of 3000 fathom troughs is that which commences off the south shore of Eastern Cuba, having there a depth of 3000 to 3180 fathoms. It is within 20 miles of this non-volcanic shore, and nearly three times this distance from Jamaica. No sufficient reason appears at present for pronouncing its origin volcanic. It is continued in a west-by-south direction to a point beyond the meridian of 85° W. or over 700 miles, making it a very long trough, and the depths vary from 2700 to 3428 fathoms. The depression extends on into the Gulf of Honduras, carrying a depth of 2000 fathoms far toward its head, and in a small indentation of the coast it stops; for nothing of it appears in the outline of the Pacific coast or the depths off it, and nothing in the range of volcanic mountains on the coast. Against the three deepest parts of the trough there are, *first*, the Grand Cayman reef, 20 miles north of a spot 3428 fathoms deep; *second*, banks in 13 and 15 fathoms within 15 miles of a depth of 2982 fathoms; and *third*, Swan Island reef, 15 miles south of a depth of 3010 fathoms; the first of the three indicating a slope to the bottom of 1:5, and the last of 1:4·4. Why these greatest depths in the trough, so abrupt in depression, should be on one side of shoals or emerged coral reefs, it is not easy to explain; and the more so that the part of the trough south of Cuba has nothing volcanic near by in the adjoining mountain range, and the fact also that the westernmost end of the trough extends on for 175 miles, and there has a depth of 3048 fathoms, with 2000 fathoms either side and no coral reefs.

D. *Arrangement of the deep sea troughs in the two halves of the oceans, pointing to some other than a volcanic origin.*

The *western* half of the Atlantic and Pacific oceans contains much the larger part of the 3000-fathom areas and all the depths over 4000 fathoms. In the North Atlantic the areas of 3000 and over in the western half, or off the United States, are very large; and the bathymetric line of 2500 fathoms extends westward nearly to the 1000-fathom line. This important feature can be appreciated for both oceans from a look at the map without special explanations.

As a partial consequence of this arrangement, the Pacific, viewed as a whole, may be said to have a westward slope in its bottom, or from the South American coast toward Japan. This westward slope of the bottom exists even in the area between

New Zealand and Australia—the ocean in this area being shallow for a long distance out on the east side and deepening to 2500–2700 fathoms close to that non-volcanic land, New South Wales, in eastern Australia. In the Atlantic, the slope is in the direction of its northeast-southwest axis, either side of the Dolphin shoal, but especially the western side, rather than from east to west, it commencing in the Scandinavian plateau and ending in the great depths adjoining the West Indies.

Owing to the system in the Atlantic topography, the Dolphin Shoal—the site of the *Atlantis* of ancient and modern fable—is really an appendage to the eastern continent, that is to Europe, and is shut off by wide abyssal seas from the lands to the west that have been supposed to need its gravel for rock-making.

But the view that the west half of an oceanic basin is always the deepest becomes checked by finding in the Indian ocean that the only areas that are 3000 fathoms deep or over are in the *eastern* part of the ocean and off the northwest coast of Australia, and near western Java and Sumatra. The greatest depths in its western half or toward Africa, are 2400 to 2600 fathoms.*

3. Conclusions.

1. The facts reviewed lead far away from the idea that volcanic action has been predominant in determining the position of the deep-sea troughs. It has probably occasioned some deep depressions within a score or two of miles of the center of activity, but beyond this the great depths have probably had some other origin.

2. It is further evident that the deep-sea troughs are not a result of superficial causes of trough-making. Erosion over the ocean's bottom cannot excavate isolated troughs. The coldest water of the ocean stands in the deep holes or troughs instead of running, as the reader of Agassiz's volume has learned.

The superficial operation of weighting the earth's crust with sediment, or with coral or other organic-made limestone, and filling the depressions as fast as made, much appealed to in explanations of subsidence, has not produced the troughs; for filled depressions are not the kind under consideration. More-

* In the Arctic seas, going north from the Scandinavian plateau, the water deepens north of the latitude of Iceland, between Greenland and Spitzbergen, to 2000 fathoms, and farther north to 2650 fathoms, in the latitude nearly of Greenwich; and it is probable that the 2000-fathom area extends over the region of the North Pole. The continents of Europe (with Asia probably) and North America, are proved by the shallow soundings over the adjoining Arctic seas and the islands or emerged land, to extend to about 82½° N., which is about 450 miles from the pole.

over, the areas are out of the reach of continental sediments and too large and deep to come within the range of possibilities of organic sedimentation or accumulation. The existence of the troughs is sufficient proof of this. The deep troughs of the West Indian and adjoining seas are in a region of abundant pelagic and sea-border life, and yet the marvelous depths exist. And the depths of the open oceans are no less without explanation. Those close by the Bahamas extending down to 16,000 and 18,000 feet, are evidence of great subsidence from some cause; and the coral reefs for some reason have manifestly kept themselves at the surface in spite of it.*

3. If superficially acting causes are insufficient, we are led to look deeper, to the sources of the earth's energies, or its interior agencies of development, to which the comprehensive system in its structure and physiognomy points. Whatever there is of system in the greater feature lines, whether marked in troughs or in mountain chains, or island ranges, must come primarily from systematic work within. The work may have been manifested in long lines of flexures or fractures as steps in the process, but the conditions which gave directions to the lines left them subject to local causes of variation, and between the two agencies, the resulting physiognomy has been evolved.

We have from the Pacific area one observation of a volcanic nature bearing on the comprehensiveness of the system of feature-lines in the oceans, and although I have already referred to it, I here reproduce the facts for use in this place.

If the ranges of volcanic islands were, in their origin, lines of fissures as a result of comprehensive movements, the lines should continue to be the courses of planes of weakness in the earth's crust. The New Zealand line, including the Kermadec Islands and the Tongan group, has been pointed to as one of these lines, and one of great prominence, since it is the chief northeastward range of the broad Pacific, and nearly axial to the ocean. The series of volcanoes along the axis of New Zealand is in the same line. It was noticed, at the Tarawera eruption of 1883, that *four or five days after* the outbreak, and three after it had subsided, White Island, in the Bay of Plenty, at the north end of the New Zealand series, became unusually active; and *two months later* there was a violent eruption in the Tonga group, on the Island of Niuafou. The close relation in time of the latter to the New Zealand erup-

* The migrations from South America alluded to in a note to page 195, proving an elevation of 2000 feet to make it possible, prove also that a large part of the West India seas *afterward* suffered subsidence in the Quaternary. How far the Bahama and Florida region participated in the subsidence is not known. That it did not participate in it has not been proved.

tion is referred to by Mr. C. Trotter, in Nature of 1886, Dec. 7.* May it not be that these disturbances were due to a slight shifting or movement along a series of old planes of fractures, taking place successively from south to north; and, hence, that even now changes of level may take place through the same comprehensive cause that determined the existence of the earth's feature lines? Owing to the long distance of the Tonga group from New Zealand an affirmative reply to the question cannot be positively made. But there is probability enough to give great interest to this branch of geological enquiry.

ART. XXIII.—*Description of a problematic organism from the Devonian at the Falls of the Ohio;* by F. H. KNOWLTON, U. S. National Museum.†

ON May 2, 1887, the Smithsonian Institution received from Mr. John H. Lemon of New Albany, Floyd Co., Maryland, a box of material collected by him at the Falls of the Ohio. The material consists of a piece of very porous and highly fossiliferous chert about five inches square, and is accompanied by a small phial containing what the sender describes as "small shells which were picked from the dust of crushed Devonian chert." The so-called shells may be seen in small numbers scattered through the matrix, thus leaving no doubt as to the correctness of the assertion that they actually come from the same horizon.

The formation from which the material comes is the Corniferous limestone of the Lower Devonian. It is, of course, a marine deposit, and the material examined contains, besides the problematic organisms, numerous examples of two species of coral (*Zaphrentis sp.* and *Cladopora sp.*) and two Brachiopods (*Streptorhynchus Chemungensis* var. *pandora* Hall, and *Spirifera gregaria* Clapp), which have been identified for me by Mr. Chas. D. Walcott of the U. S. Geological Survey. These problematic organisms were first sent to Mr. Walcott under the impression that they were foraminiferous shells, but as he failed to recognize any foraminiferal characters and regarding them as more probably of vegetable origin, he sent them to the Department of Fossil Plants.

The organisms under consideration are minute, spirally grooved bodies from 1·50 to 1·80 mm. long and about 1·70 mm.

* This Journal, III, xxxiii, 311.

† Published by permission of the Assistant Secretary of the Smithsonian Institution.

broad. They have been hollow spheres and the now solid interior has probably been infiltrated through the very small orifice at one extremity (See fig. 2). The outer wall has been

moderately thick and when broken away, leaves impressed upon the nucleus, lines indicating the position of the spirals. (See fig. 3). The "shell" breaks away very easily and it is a matter of some difficulty to obtain absolutely perfect specimens from the matrix. I am unable to detect structure in the outer wall. Ten, or perhaps rarely nine, spirals (cells?) have entered into the composition of the "shell" (sporostegium?). About eight turns of the spiral are visible in lateral view.

The figures and description, it will be observed, correspond very closely, at first sight, to the well known "fruits" of the genus Chara, and the probability of their being fruits of this kind is greatly strengthened when it is remembered that more than forty species have been described in a fossil state, and as I am informed by Prof. J. D. Dana, they have actually been referred with little hesitation to the genus Chara by the late Prof. F. B. Meek, who examined material from this same locality many years ago. Prof. Meek writes of them as follows:* "In the same matrix with the above described shell (*Trichonema tricarinata* Meek) I have been surprised to notice numerous minute bodies that I can scarcely doubt are really the fruits of the fresh-water genus Chara. At any rate, they seem to present all the external characters of the same. These little bodies are globose, about 0·05 of an inch in diameter, and each ornamented by nine strongly defined and very regularly disposed spiral ridges, which start on one side around a minute pit, and pass with perfect regularity spirally, so as to converge to an exactly opposite point on the other side, making each about one spiral turn in passing from side to side. If really the seeds of this fresh-water genus of plants, they must have been carried into the sea by streams, and deposited where we now find them, along with numerous marine shells." This description agrees so closely with my own that there can be no doubt that the specimens are the same.

* Fossils of the Corniferous Group: Geol. Surv. of Ohio, Palæontology, vol. i, 1873, p. 219, Note.

Prof. Dana also refers briefly to these organisms described by Meek, in his Manual of Geology (Ed. 1875, p. 259).

As the lowest point at which unquestioned Chara has been found fossil is the Muschelkalk of Moskau, the discovery of a species in the Devonian would naturally excite great interest, for it would then be shown that the genus was much older than is generally supposed. This led to a more detailed examination of the material, when it was found that they could not possibly be referred to Chara as ordinarily accepted, since in all the known species, both living and fossil, the sporostegium is composed of five cells twisted to the left, while in this the spirals (sporostegia?) are nine or ten in number and *twisted to the right.* There is, however, no vital objection to the supposition that this might have been an archaic or original type from which the more modern forms have been developed. This view is amply confirmed by what we already know of the lines of development that have been followed by some well known types of vegetation, as for example the conifers.

In order to be more certain in the matter, the specimens and drawings were submitted to Dr. T. F. Allen of New York, the well known authority upon the *Characeæ.* He was at once struck by their resemblance to the fruits of Chara and immediately wrote* that it was probably a new type, a new genus, "still descended direct from the Floridæ, perhaps, and grown in salt water. The whole plant must have twisted to the left, because our plants now twist *opposite* to the twist of the sporostegium; or perhaps the twist changed when only five cells enveloped the spore." Dr. Allen also suggested their resemblance to the so-called Rhizopod *Saccammina?* (*Calcisphæra*) *Eriana* described by Dawson from the Corniferous limestone of Kelley's Island near Sandusky, Ohio; a paper that had been before overlooked. On referring to the article in question,† it is at once apparent that the specimens under consideration certainly have a very marked resemblance to those described by Dawson. They are described by him as follows: ". . . they are minute globular bodies, one millimeter in diameter, and occur in great numbers in light gray limestone containing *Stromatopora,* crinoidal joints and corals, as well as multitudes of minute organic fragments. The exterior surface of the specimens is dull or granular in aspect, and either smooth or marked with slight spiral ridges, giving an appearance which at first sight suggests a resemblance to the spore-cases of *Chara.* On microscopic examination, they are found to be hollow spheres filled with calcite introduced by infiltration, having one small aperature; and the test or wall of the sphere presents a granular appearance as if composed

* In Litt., April 9, 1888.

† Canadian Nat., New Ser., vol. x, p. 5.

of fine calcareous grains. . . . It can scarcely be anything else than a Rhizopod, probably allied to the modern *Saccammina globosa*, or to the Carboniferous *S. Carteri*, though much smaller than either, and differing in its tendency to external ornamentation. It is, of course, possible that a test of this kind might belong to an animal of very different character from *Saccammina*, but in the present state of knowledge of such forms, I think it quite justifiable to refer it to this genus."

In a note appended to the above article (l. c., p. 8), Dawson says, "In a letter just received from Mr. H. B. Brady, he says that he knows of no rhizopod test, recent or fossil, precisely corresponding to the little Erian fossil above described. He says—'the more I examine your little fossil the more confident I am that it bears no relation to any rhizopod type that I know.' It will then be seen that he does not admit its affinity to *Saccammina* and that he even doubts as to its rhizopodal character."

I am not aware that any further examinations have ever been made of these Kelley's Island specimens by Dawson.

After submitting the specimens and drawings from the Falls of the Ohio to Dr. A. Nordstedt, the distinguished Swedish authority on *Characeæ*, Dr. Allen writes:* "After repeated investigations, comparisons, and correspondence, we must come to the conclusion that the little seeds you sent me are Foraminifera and not Chara. I enclose Dr. Newberry's decision in the matter. There are two distinct features about this matter, which cannot be overlooked. The first is that these bodies are very uniformly diffused through the rock; this certainly would not be the case were they seeds of any Chara. The second point is that these rocks were formed under a considerable depth of salt water. Now while some species of Chara are known to inhabit salt water, they are as a rule, found near the mouth of large streams and are not found in any great depth of salt water; indeed, Chara will not grow out of the reach of sunlight, and ten to fifteen feet in depth is the limit of growth in Chara."

Dr. J. S. Newberry, as referred to above, is of the opinion that these organisms are unquestionably identical with the *Saccammina* of Dawson. He suggested that they be submitted to Mr. H. B. Brady, of London, the well-known authority on the Foraminifera. This was accordingly done, and from him the following reply has been received:† "I am duly in receipt of your letter, enclosing specimens and drawings. The minute spiral organism sent is not altogether unknown to me. I do not in the least believe it to be Foraminiferal. In

* In Litt., June 20, 1888.

† In Litt., July 2, 1888.

point of minute structure it shows no approximation to any type of Foraminifera with which we are acquainted. Like yourself, I should have set it down as the nucleus of a Chara, or some closely allied organism, and if it be not that, I should seek for affinities amongst the calcareous Algæ. The so-called *Saccammina* (*Calcisphæra*) *Eriana*, I have not much doubt, belongs to the same or a closely allied group, but I have never been able to accept it as a Foraminifer.

It is a very rare, almost unknown thing, to find Foraminifera of any one species in any deposit, recent or fossil. There are often two or three species, or a very limited number, but where one exists in abundance my experience is, one always meets with a few specimens among allied forms."

In the hope that it might find a resting place among the calcareous Algæ, the specimens and drawings were next sent to Prof. W. G. Farlow, of Cambridge, who reports upon them as follows:* "At first sight, the specimens you send certainly appear to be more like the spores of Chara than any other plant. In saying that the bodies were not Chara spores I presume Nordstedt was influenced by the fact that there appear to be more than five spirals.

Query. Would it be impossible that there are Charas with a different number of spirals than in living species?

With regard to the question of the possibility of the bodies being Algæ, I presume that the suggestion arose in consideration of Meunier-Chalmas's discovery that some supposed Foraminifera were really portions of Algæ. The Algæ in question are all *Siphonocladiæ* of which *Bornatella* appears to be both recent and fossil. I do not think it possible that your fossil could belong to this group. When whole they are columnar or with stalks and they can only be mistaken for Foraminifera when the radiating disks are broken off and separate.

Your fossil is globular. The fragments of *Siphonocladiæ* are disk-shaped and composed of numerous cells, and all are much larger than what you send. Nor is it at all probable that they are spores of this or any other group of Fungi. I know none grooved in this way. Besides, the spores of *Siphonocladiæ* are not calcareous, as a rule, but are soft. The sporangium is calcareous but does not at all resemble your fossils. The spores would hardly be likely to survive as fossils.

In *Siphonocladiæ* the external cells may be decidedly calcareous, but if broken off from the rest, which is not apt to be the case, the incrustation would not be grooved, but uniform except at the ruptured spot.

In short the fossil is very much less like any Algæ than like Chara spores, and they have already been excluded by competent experts."

* In Litt., Oct. 23, 1888.

These problematic organisms which have been excluded from the Characeæ, Foraminifera, and the calcareous Algæ, were described and exhibited informally to several members of the Washington Biological Society, in the hope that some one might be able to suggest a possible relationship. Dr. Th. Gill suggested their resemblance to certain ova-capsules of Mollusks and Hydroida. Dr. W. H. Dall, to whom they were shown, was also at first struck by the resemblance between these organisms and the ova-capsules of Mollusks, but after a careful examination concluded that they could not possibly belong to them as the shell of the organism is very thick and calcareous while the ova capsules of the Mollusks are uniformly thinner and not calcareous, but chitinous, which would not be likely to be changed in fossilization. Mr. Richard Rathbun, of the U. S. Fish Commission, also denied the possibility of their being eggs or ova-capsules of star-fish.

As to their resemblance to the gonangia of the Hydroida, an examination of the Monographs by Allman in the Challenger Reports shows it to be impossible. One of the species most resembling it is *Calamphora parvula* All.*; but the gonangia stand upon well marked stalks and they are described as "distinctly annulated" while these organisms are no less distinctly spiral, and without positive evidence of a stalk or pedicel.

The only other point which it now remains to consider in this connection is the result of the observations made by Professor W. C. Williamson and recorded in number X of his invaluable memoirs "On the Organization of the Fossil Plants of the Coal Measures." Having formerly shown that one of the supposed Carboniferous Foraminifera was really a plant he has been lead to examine several other Carboniferous forms, thinking it probable that some of them might also be proven to be vegetable and not animal. The organisms investigated by Professor Williamson were mentioned by Professor Judd before the Geological Society of London†. He regarded them as undoubted *Radiolarians.* They come from the limestone rock near Rhydymwyn which is near Mold, in Flintshire. It was impossible to separate the organisms from the matrix and the only means of studying them was by thin sections. They are shown to be hollow spheres, "most of which are furnished with varying forms of peripheral appendages." Several forms are named by Williamson, in some of which the wall of the sphere is structureless, while in others it is described as "double, but the inner and outer layers enclose between them numerous small cubical compartments separated by radiating partitions. The compartments are filled, like the central sphere

* Challenger Reports, vol. xxiii., Pl. x, fig. 3a.

† Quart. Journ. Geol. Soc., vol. xxxiii, Lond. 1877, p. 835.

cavity, with infiltrated translucent calcic carbonate." The peripheral marking, as stated above, varies greatly, some being perfectly smooth, others provided with long irregular projections or spines. None seem to be distinctly spiral.

Professor Williamson examined at the same time examples from Kelley's Island of the *Saccammina* of Dawson. Of these he says: "Like the Welsh specimens, they have been more opaque than the surrounding matrix, when viewed by transmitted light. * * * Each organism has been a hollow sphere. The sphere wall has been much thicker in proportion to its entire diameter than is the case among the Welsh specimens. Externally the transverse section of each sphere presents an undulating outline, due to the intersection of prominences and ridges that characterize its surface. Sometimes these projections surround the entire section, but more frequently they are absent from limited portions of the periphery. Occasionally these ridges may be seen pursuing an oblique direction like the bands across the nucleus of a *Chara*. The central cavity is always occupied by crystalline infiltrated carbonate of lime. Though the sphere wall often exhibits a granular texture, I discovered a radiating structure in a sufficient number of the specimens to convince me that in this respect they have closely resembled some of the Welsh specimens." In conclusion he says: "Whilst I am thoroughly satisfied that these objects are *not Radiolarians*, it is not easy to say what they are."

In order that these organisms may be distinguished they have been referred by Professor Williamson to a provisional genus *Calcisphæra*, created for the purpose. The Kelley's Island form is called *Calcisphæra robusta*.

The Calcisphæra of Williamson has still later been found by Wethered in the Carboniferous Limestone of Gloucestershire.* After discussing the views held by Professor Judd and Professor Williamson he concludes that "the tests were originally calcareous and not siliceous." "This was urged as a strong argument against regarding the organisms as Radiolaria, and the author, while considering it unwise to come to a decided opinion, believed it safe to say that they are Protozoa."

The evidence in regard to the nature of this most puzzling organism has been passed in review. It will be observed that the first impression of almost all who have examined it has been that it is a "fruit" of Chara. The principal objection to this view is that the sporostegium has nine or ten cells, while all the heretofore discovered species, both living and fossil, possess only five cells. There is also the difference in the direction of the spiral. The further objection that the organisms are too uniformly distributed throughout the matrix to be

* Quart. Journ. Geol. Soc., vol. xliv, p. 91, Lond. 1888.

Chara does not seem to be well taken since we have abundant examples of the shells of small mollusks very evenly distributed through the matrix. The objection that Chara could not grow in the depth of salt water indicated by the numerous corals and Brachiopods, is much more serious and may be fatal to the view that it can be Chara. Be that as it may, the evidence both *pro* and *con* is presented, and it is to be hoped that some one may be able to relegate it ultimately to its proper systematic position.

In order that these organisms from the Falls of the Ohio may be referred to independently I propose to call them *Calcisphæra Lemoni* after the collector, particularly as I can not regard them as Foraminiferal and identical with Dawson's *Saccammina*, and moreover the name *Calcisphæra* is not misleading whatever their nature may eventually be proved to be.

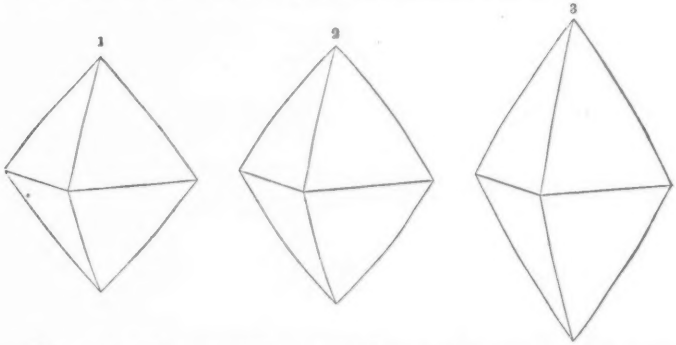
ART. XXIV.—*On some curiously developed pyrite crystals from French Creek, Delaware Co., Pa.;* by S. L. PENFIELD.

ORDINARILY simple octahedrons and cubes of pyrite occur at French Creek, Pa., while occasionally rarer combinations are met with, as the cube with $\pi(420)$, $\frac{1}{2}(4\text{-}2)$. The crystals are bright and have a good luster, but are usually covered with vicinal faces and are sometimes quite distorted by them. The crystals, which are to be especially described in the present article, are five which are in the collection of Mr. C. S. Bement of Philadelphia, and two in the collection of Professor Geo. J. Brush of New Haven, and I take pleasure in expressing my thanks to these gentlemen for their generosity in placing the crystals at my disposal for study. They are in all cases isolated crystals, built out in all directions and showing no attachment. I have been unable to obtain any exact information as to their mode of occurrence, and can only state that they are very rare and are from the iron mines of French Creek.

The special peculiarity of these crystals is that they are abnormally developed, i. e., lengthened out, in the direction of one of the crystallographic axes. If we take this direction as the vertical, the crystals will appear either as steep tetragonal or orthorhombic pyramids. In all cases the pyramidal faces are curved toward the apex and as a result of this the pole edges, running from the lateral to the vertical axes, are curved while the middle edges, running between the lateral axes, are perfectly straight. Owing to this curving the angles between the faces can not be measured with the reflecting goniometer

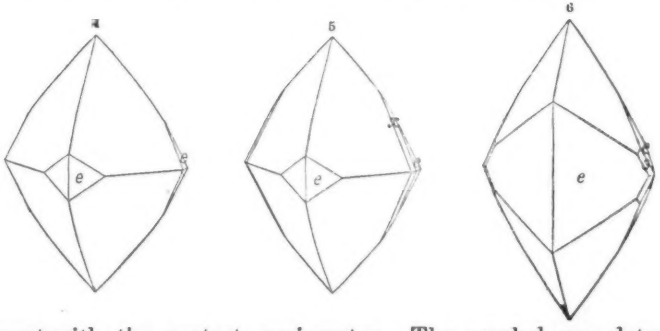
and admit of only approximate measurement with the contact goniometer. The crystals have a remarkably perfect geometrical development, that is, similar faces are developed to almost exactly the same size and extent.

The first three crystals to be described, which are in the Bement collection, appear as tetragonal pyramids. By measurement of the interfacial angles over and near to the middle edges the faces were found to be steep enough to cut the vertical axes at 1·25, 1·50 and 1·80 respectively, but owing to the curving the distances at which the faces actually intercept the vertical axes are less. Figures 1, 2 and 3 represent the three crystals, drawn with the same length of the lateral axes and with the pole edges straight for a short distance from the lateral axes and steep enough to cut the vertical axes at 1·25, 1·50 and 1·80 respectively, but curved toward the top so that the vertical axes are really cut at 1·16, 1·25 and 1·50 respectively, according to actual measurement of the diameters of the crystals. The crystals are of good size and measure in the direction of the vertical axes respectively, 22, 22 and 33^{mm}.



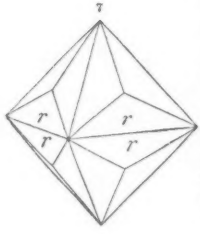
The remaining crystals are perhaps more interesting owing to the occurrence of pyritohedral or pentagonal dodecahedral faces, which in all of the crystals occur only at the extremities of the lateral axes. The faces are rough, but approximate measurements with the contact goniometer determine the crystals to be the ordinary pyrite form $e, \pi(210), \frac{1}{2}(i\text{-}2)$. The pyramid is in all cases the curved $\frac{3}{2}$ form, r, like fig. 2. The pyramid faces are always striated near to and about the front pyritohedral faces, the striæ being a little steeper than the combination edge between e and r and having about the direction of the combination edge $\pi(421)$, $\frac{1}{2}(4\text{-}2)$ and r. The pyritohedral faces have very different shapes at the extremities of the two lateral axes and the crystals, having only three symmetry planes, resemble orthorhombic forms. The two crystals in the Brush collection,

which are so nearly alike that they can not be told apart, are represented in fig. 4. Fig. 5 represents a crystal in the Bement collection where the edges between the *e* faces at the sides and *r* are replaced by a form *x* in the zone *e*, *r*. The *x* faces are all rough and admit of only approximate measure-



ment with the contact goniometer. The symbol was determined to be (6, 12, 7), $2\text{-}\frac{12}{7}$. There are only eight of these faces instead of the twenty-four which we should expect in an ordinary pyrite crystal. Fig. 6 represents a crystal in the Bement collection in which the *e* faces are larger. This is the most unsymmetrical of all the crystals; on the side, which is turned away from the observer, the *e* faces are so large that the front and side ones just meet forming a solid angle and leaving none of the middle edges between the lateral axes; on the other side, which is shown in the figure, the *e* faces are still larger and the edges between them are replaced by the small *s* faces 231, $3\text{-}\frac{3}{2}$. The *s* faces were bright and admitted of approximate measurements on the reflecting goniometer giving $s \wedge s$, $231 \wedge 23\bar{1} = 30°\ 40'$, calculated $31°\ 0'$. These *s* faces differ from the ordinary pyrite combination, for with 210 and 021 usually 321, 132 and 213 occur in one octant, while here only one of the alternating faces 231 occurs.

All who have seen these crystals pronounced them the most curious and interesting pyrite crystals that they have ever seen.



Why they have been distorted in this peculiar way I cannot venture to say. Some law must have governed them for they all have such perfect, though lower than isometric, symmetry. It is perhaps the result of the vicinal development of the faces which is so common at the locality. If in fig. 7, which is the ordinary isometric trigonal-trisoctahedron 332, $\frac{3}{2}$, the four *r* faces in front and the corresponding ones behind were ex-

tended they would give a tetragonal pyramid like fig. 2, except that fig. 2 has been somewhat shortened by the curved nature of the faces. The curious forms which we have been considering I prefer to regard as abnormally developed trigonal-trisoctahedrons. That they are really isometric is proved by the occurrence of the ordinary pyrite form $\pi(210)$, $\frac{1}{2}(i\text{-}2)$. The behavior of one of the curved crystals on the reflection goniometer is also quite striking. Measuring from pyramid to pyramid over the vertical axis the very points gave sharp reflections of the signal and then on turning the crystal there followed an unbroken band of light, with no sharp reflection of the signal, as long as different parts of the curved surfaces were in a position to reflect the light. The angle between the sharp reflections of the signal, obtained from the very minute flat surfaces at the points, was found to be 109° 36′, calculated for $o \wedge o$ $(111 \wedge \bar{1}\bar{1}1)$ 109° 28′. We see from this that our steep $\frac{3}{2}$ pyramid at the base, becomes by the curving gradually flatter till it corresponds to a unit pyramid or octahedron at the vertex.

The specific gravity of two of the crystals represented in figs. 2 and 4 was found to be 5,016 and 5,022 respectively.

I would also mention here a specimen from French Creek which has been in Professor Brush's collection since 1850. The pyrite crystals which are implanted on magnetite are very flat trigonal-trisoctahedrons, appearing at first sight like octahedrons. These are the only crystals which I have seen from this locality where the vicinal faces form a distinct and clean cut pyramid on the octahedron faces. The faces, however, are not perfect enough to give a distinct and single reflection with the goniometer. The angle between two of the faces is not over 3° 50′ and consequently the value of m in the symbol ma, a, a cannot exceed $\frac{1}{1}\frac{3}{2}$ although it is useless to assign a definite symbol to faces where the angle cannot be measured more exactly, and where a slight variation in the angle causes a very decided change in the symbol.

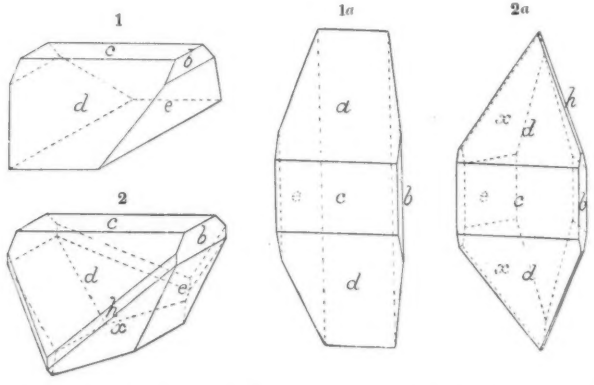
Mineralogical Laboratory, Sheffield Scientific School, Dec. 18th, 1888.

Additional note.—Very recently Mr. Geo. L. English of Philadelphia sent me a suite of French Creek pyrites from his private collection containing six of the elongated pyramids, mostly of the fig. 4 type, also a number of cube octahedron and pyritohedron combinations which are modified and rounded by the occurrence of vicinal faces and one crystal, forming a sort of connecting link between an octahedron and the fig. 2 type, where the octahedron and some trigonal trisoctahedral faces round off and blunt the apex of the pyramid. He also informs me that the isolated crystals occur imbedded in calcite. S. L. P.

ART. XXV.—*Crystallized Bertrandite from Stoneham, Me., and Mt. Antero, Colorado;* by S. L. PENFIELD.

1. *Stoneham, Maine.*

FOR the bertrandite from Stoneham, Me., the second locality in the United States,* I am indebted to Mr. George F. Kunz of New York. He states that, at the time herderite was found and described by Mr. Hidden,† he noted the small crystals occurring in pockets with the herderite and laid them aside as an unknown mineral; the quantity was too small to warrant any further investigation at the time. Becoming convinced, after the identification of bertrandite at Mt. Antero,‡ that his crystals were the same mineral he generously turned them over to me for identification and description. Only a few specimens were observed and the crystals were all small, the largest of the three which were detached for measurement being about 2·5^{mm} long by 1·5^{mm} broad. The luster of the faces is not very perfect and the measurements with the reflecting goniometer not as good as could be desired. The habit of the crystals is unlike anything that has been previously described and as it throws considerable light on the crystallization of the mineral is worthy of a detailed description. The forms which were observed were as follows:



c, 001, *O*; *b*, 010, *i*-$\bar{1}$; *h*, 130, *i*-$\bar{3}$: *d*, 102, $\frac{1}{2}$-$\bar{1}$; *e*, 03$\bar{1}$, 3-$\bar{1}$ and *x*, 16$\frac{2}{3}$, 3-$\bar{6}$.

The simplest combination is shown in fig. 1, where the faces *c* and *d* are prominent at one end of the vertical axis and *c*

* In a letter, dated Sept. 26, 1888, Mr. W. E. Hidden announced to us that he had identified bertrandite (or a new mineral) on specimens of herderite from Stoneham.—EDS.

† This Journal, III, xxvii, 135, Feb., 1884. ‡ Ibid., III, xxxvi, p. 52, 1888.

and e at the other. This can be explained most readily by considering the crystal as hemimorphic in the direction of the vertical axis. As in our ordinary crystallographic projection the figures of our crystals are very much fore-shortened in the direction of the brachy axis $\breve{a}$, and as the bertrandite crystals are elongated in this direction, I have re-drawn fig. 1 making $\breve{a}$ the vertical axis, c the front and leaving $\bar{b}$ unchanged as in fig. 1a, which gives a very good idea of the crystals. Figures 2 and 2a drawn the same as above represent a more highly developed crystal. The most conspicuous faces on these crystals are c and d above, both of which are highly polished and give good reflections. The faces at the other end of the c axis are by no means as good, the luster is poor and the faces oscillate and combine with one another in such a way that the edges are not sharp and continuous; this is especially the case when x is present. The x faces are not sharp and well defined but round off the ends of the crystal in such a way that they do not form straight edges with c and e; they gave also no sharp reflection of the signal with the goniometer. Approximate measurements, however, and the occurrence of the faces in the zone d and h determine its indices to be $16\bar{2}$ (3-$\breve{b}$). The brachy-pinacoid b gave fairly good reflections, h was in all cases small and gave faint reflections. One twin crystal was observed, the basal plane c being the twinning plane and the d faces making a very prominent reëntrant angle. The crystals are usually attached at one end of the brachy axis and as only one of the bright d faces is conspicuous they have a very decided monoclinic appearance. In one of the detached crystals part of a second d face was present developed as in the figures and showing that the crystals are truly hemimorphic and not monoclinic. In detaching one of the crystals a very perfect cleavage parallel to b was developed which has not been observed before; the highly perfect prismatic and basal cleavages were also observed, the same as in the Mt. Antero crystals. If we take the best measurements which were obtained,

$$c \wedge d,\ 001 \wedge 102 = 27^\circ\ 42'\ \text{and}$$
$$m \wedge m,\ 110 \wedge 1\bar{1}0 = 59^\circ\ 16',$$

the latter being cleavage faces, we obtain the axial ratio given below, while for comparison the ratio obtained from the Mt. Antero mineral is also given:

Stoneham, Me. $c : b : a = 0{\cdot}5973 : 1 : 0{\cdot}5688$
Mt. Antero, Col. $c : b : a = 0{\cdot}5953 : 1 : 0{\cdot}5723$

I am inclined to give the preference to the measurements on the Stoneham crystals; if so, the angles which have been measured and the calculated values are as follows:

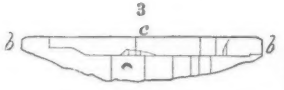
	No. 1.	No. 2.	Calculated.
$c \wedge d$ 001 $\wedge$ 102 =	27° 40′	27° 42′	27° 42′
$c \wedge e$ 00$\bar{1}$ $\wedge$ 03$\bar{1}$ =	60° 22′	60° 53′	60° 50′
$c \wedge e$ 001 $\wedge$ 0$\bar{3}\bar{1}$ =	60° 58′	60° 50′	60° 50′
$c \wedge b$ 001 $\wedge$ 010 =	90° 1′		90°
$m \wedge m$		59° 16′	59° 16′
$b \wedge h$ 010 $\wedge$ 130 =		29° 30′	30° 22′

The crystals are not very transparent and favorable for the determination of the optical properties; in converging polarized light with the microscope, an obtuse bisectrix was seen normal to *c*, the plane of the optic axes being the brachypinacoid.

The specific gravity was carefully taken, by just floating the mineral in the Thoulet solution, and found to be 2·598, exactly the same as that found for the Mt. Antero bertrandite. The material being very limited no chemical tests were made.

2. *Bertrandite from Mt. Antero, Colorado.*

In a previous communication* I described crystals from Mt. Antero which had a curious hemimorphic development. The crystals were composed of the three pinacoids; but while one of the basal planes was flat the other was rounded and striated parallel to the *ă* axis by oscillatory combinations of the basal plane with a brachy-dome, probably 011. Figure 3 represents a section across one of the Mt. Antero crystals parallel to the macropinacoid which was drawn with a camera lucida and magnified 17 diameters. During the past summer a number of bertrandite specimens were found and all of them showed this peculiarity. Some of the crystals which are now in the collection of Mr. C. S. Bement of Philadelphia, are 25^{mm} long, 8^{mm} wide and 3^{mm} thick. That the rounding of one of the basal planes is not accidental, but is owing to a hemimorphic development of the crystals, cannot be doubted. As proof of this, one of the largest crystals was tested for pyro-electricity by the admirable method proposed by Prof. A. Kundt.† The crystal was heated in the air-bath to 100° C. and on cooling was dusted with a mixture of red oxide of lead and sulphur. The experiment was most satisfactory, the flat basal plane showed strong positive electricity and became coated with the yellow sulphur, while the rounded basal plane showed negative electricity and was coated with red oxide of lead.



Tests for pyro-electricity were also made on the Stoneham crystals but they were so small that it could scarcely be deter-

* This Journal, III, xxxvi, p. 52, 1888.

† Annalen der Physik u. Chemie, xx, p. 592, 1883.

mined with certainty. It seemed, however, as if the basal plane in combination with the *d* face showed positive electricity, the same as the flat basal plane of the Mt. Antero crystals, while the other basal plane showed negative electricity.

In closing, I wish to express my thanks to Messrs. George F. Kunz and C. S. Bement, who provided me with material for study and to Mr. George L. English of Philadelphia, who sent me a large number of Mt. Antero crystals for examination.

Mineralogical Laboratory, Sheffield Scientific School, Dec. 12, 1888.

Art. XXVI.—*Mineralogical Notes;* by J. S. Diller.

1. *Dumortierite from Harlem, N. Y., and Clip, Arizona;* by J. S. Diller and J. E. Whitfield.

In this Journal for Nov., 1887, p. 406, Dr. R. B. Riggs published a description, including a chemical analysis, of "The so-called Harlem Indicolite," which was regarded as probably a new boro-silicate. The notice led to correspondence with Prof. E. S. Dana, who identified the mineral as dumortierite and kindly sent us some of the original dumortierite from near Lyons, France, for comparison.

The physical properties of the Harlem dumortierite agree very closely with those mentioned by Bertrand,* Gonnard† and Damour.‡ Crystals are very rare. An imperfect one§ has been observed with $a(\infty\breve{P}\infty)$ and $m(\infty\breve{P})$ equally developed. Both planes are striated parallel to the vertical axis. Indistinct reflections allowed only approximate measurement $am = 152°$, and therefore $mm = 124°$. Obtuse terminal planes rarely observed on embedded crystals.

Cleavage parallel to *a* is distinctly developed so that when the mineral is crushed and examined under a microscope cleavage plates may be found which show an obtuse bisectrix lying parallel to $b(\infty\breve{P}\infty)$. Cross fractures occasionally yield basal sections which may be made to exhibit an acute bisectrix. Extinction always takes place parallel to the vertical axis and the

* Bull. Soc. Min. d. France, vol. iii, p. 171, 1880, and vol. iv, p. 9, 1881.
† Bull. Soc. Min. d. France, vol. iii, p. 2, 1881.
‡ Bull. Soc. Min. d. France, vol. iv, p. 6, 1881.
§ It was kindly loaned to us by Mr. R. T. Chamberlin of New York. Our thanks are also due to Mr. Geo. F. Kunz for the material he so generously furnished for this investigation. It was collected along Fourth Avenue at 120th and 122nd Streets as well as near Ft. George, a new locality of the same district.

mineral is evidently rhombic.* In cross sections imperfect cleavage is rarely seen parallel to some prismatic plane. Polysynthetic twinning is very common parallel to *b* as well as other planes in the prism zone. Liquid inclusions and long tubular cavities parallel to the vertical axis are abundant. Hardness =7 and sp. gr. slightly above 3·265.

The rock in which the dumortierite occurs at Harlem is the pegmatoid portion of a biotite gneiss. These coarse vein-like parts are composed of quartz with both red and colorless orthoclase, some plagioclase and tourmaline. The other portions of the rock contain much biotite and garnet. The fibers of dumortierite are sparingly scattered through the quartz in the coarse granular rock. A few were observed penetrating plagioclase. The thin thread-like fibers are occasionally so small as not to be distinctly dichroic, but they are intermingled and connected with larger dichroic fibers by every intermediate gradation in size, so that an observer at once regards them all as the same mineral. They sometimes closely resemble the trichitic forms in granitic quartz which Dr. G. W. Hawes† and many others following his suggestion, regarded as rutile.

The presence of tourmaline in the rock at Harlem was not at first recognized. It is so intimately associated with the dumortierite that they cannot be easily separated. Their pleochroic phenomena, however, are so unlike that they can be readily distinguished under a polarizing microscope. The presence of tourmaline renders the results of Mr. Riggs' analysis less trustworthy. By means of the Klein solution and an electro-magnet the tourmaline was separated from the dumortierite. The ·217 gram of the latter thus obtained was analyzed with the following result.‡ Only the smallest trace of B_2O_3 was observed.

SiO_2 31·44 Al_2O 68·91

Fortunately, at the time it became particularly desirable to obtain a larger quantity of dumortierite for analysis a collection of minerals was sent by Mrs. C. A. Bidwell from Clip, Yuma Co., Arizona, to the National Museum for identification. Among them Prof. F. W. Clarke noticed a blue mineral which proved to be dumortierite. It is finely fibrous and so abundant as to give color to the rock which is composed chiefly of granular quartz. A few grains of magnetite and limonite are the only other minerals intermingled with the quartz and dumortierite, so that it seems an easy matter by means of a heavy solu-

* My observations, noted in Mr. Riggs's paper, already referred to, were very hastily made with imperfect apparatus, and published before I had an opportunity for their revision.—J. S DILLER.

† Mineralogy and Lithology of N. H., p. 45, 1878.

‡ The chemical work for this paper was done by Mr. Whitfield.

tion and an electro-magnet to obtain the latter mineral for chemical analysis. The results are given under I, below.

These figures appear to show the material analyzed to be impure and it was thought advisable to obtain more of the rock and endeavor to separate the dumortierite as far as practicable from all impurities. Mrs. C. A. Bidwell kindly furnished a sufficient amount of much better material in which the only mineral associated with the dumortierite was quartz. As dumortierite is not acted upon by hydrofluoric acid the rock after being crushed to small particles, was digested in this acid for a length of time sufficient to decompose most of the quartz. The mass was then washed with water, dried and any quartz that might still remain, separated by Thoulet's solution. After thorough washing the material was examined with the aid of a microscope and found to be free from gangue. Having been ground exceedingly fine and dried at 104° C. for about three hours the mineral was analyzed with the following results (II):

	I.		II.	
Si_2O_2	31·52		27·99	
Al_2O_3	63·66		64·49	
CaO	trace		----	
MgO	·52		trace	
Na_2O	·37		----	
K_2O	·11		----	
B_2O_3	2·62		4·95	4·93
P_2O_5	----		0·20	
Ignition	1·34	H_2O	1·72	
	100·14		99·35	

Analysis II shows less impurity than the first specimen analyzed. These results indicate either that dumortierite is not a simple silicate of alumina as stated by Damour,* or else that the material analyzed was a mixture of dumortierite with some other compound.

If we assume the formula of Damour to be correct and estimate all the SiO_2 in the analysis as belonging to the formula $Al_6Si_2O_{13}$, then there will be left unaccounted for a small amount of Al_2O_3, H_2O and B_2O_3 and these are present in the proportions represented by the formula $AlB_2O_6 . 2H_2O$. If this mode of interpretation be correct then the mineral from Arizona corresponds approximately to the formula $3Al_6Si_2O_{13}AlB_2O_6 . 2H_2O$ which requires $Al_2O_3=65·2\%$; $SiO_2=27·6\%$. $B_2O_3=5·4\%$; $H_2O=1·8\%$ agreeing quite closely with the actual analysis. A borate of alumina corresponding to the above formula is, we believe, not actually known, and concerning its properties noth-

* Bull. Soc. Min. d. France, vol. iv, p. 6.

ing can be predicted. If it exists it is certainly remarkable that it should withstand the treatment with hydrofluoric acid which the dumortierite received during the process of purification.

We are greatly indebted to Mrs. C. A. Bidwell for the supply of material for investigation, which at the cost of much personal labor she so liberally furnished.

U. S. Geol Survey, Washington, D. C., Jan. 19, 1889.

2. *Supplementary note on the Peridotite of Elliott Co., Ky.*;* by J. S. DILLER.

Dr. Geo. H. Williams recently identified perofskite in the serpentine of Syracuse, N. Y. (this Journal, vol. xxxiv, p. 140), and suggested that the yellowish grains which were supposed to be anatase in the peridotite of Elliott Co., Ky. (U. S. Geol. Surv. Bull. No. 38), may be the same mineral. To definitely identify, if possible, the mineral in question the powdered peridotitic rock was digested for a long time in HCl until there was nothing left with the yellowish mineral but a few grains of garnet, enstatite and chromite. After careful washing, the residue was subjected to the action of H_2SO_4 raised slightly above the temperature of the water bath. The yellowish grains readily dissolved and an analysis by Mr. L. G. Eakins yielded the following results:

Insoluble residue	50·79
TiO_2	22·75
FeO	5·35
CaO	10·28
Al_2O_3	1·48
MgO	2·49
SiO_2	6·13
Total,	99·27

The presence of Al_2O_3, MgO, SiO_2 and part of the FeO is due to the fact that part of the garnet and enstatite were dissolved, for after the removal of the yellowish mineral they were found to be slightly soluble under the conditions of the experiment. The analysis clearly demonstrates that the yellowish mineral is composed essentially of TiO_2 and CaO, and there is good reason to believe the mineral is perofskite as Dr. Williams suggested.

In the rock the ilmenite is frequently surrounded by a granular border of perofskite which may be so broad that the perofskite appears to completely replace the ilmenite as if derived from it by alteration. Like the perofskite in the melilite

*This Journal, vol. xxxii, p. 121.

basalt from Hochbohl by Owen, it is frequently grouped with the magnetite. In the Kentucky rock, however, the perofskite is so intermingled with dolomite and other secondary products as to suggest that it belongs in the same category. It is not found included in the central portions of ilmenite grains nor in fact in any of the primary minerals as if present at the time of their crystallization, but occurs only under such circumstances as to lead to the conjecture that it may have originated subsequently from the alteration of the ilmenite.

This opinion is rendered less probable when we remember the pyrogenous methods employed in the artificial production of perofskite, and recall the fact of the chemical stability of the ilmenite which occurs abundantly with pyrope in the sand resulting from the disintegration of the peridotitic rock.

In the same sand with the pyrope and ilmenite a lameller monoclinic pyroxene is sparingly found. The crystals are not simple as those of enstatite previously noted, but made up of a multitude of twinning lamellæ lying parallel to the orthopinacoid along which it may be readily split. Some of these pyroxenes are dull but others are clear greenish yellow like olivine.

A part of this olivine rock is holocrystalline granular like the dunites, but a much larger portion than was at first supposed is decidedly porphyritic. Numerous crystals of olivine, many of them idiomorphic, are embraced in a ground mass which has been greatly altered since its consolidation. This rock plainly belongs to the type which the late Prof. H. Carvill Lewis (Rept. of British Assoc. for Adv. of Sci., 1887, p. 721) designated kimberlite, and which Prof. Rosenbusch classes among the Pikrite-Porphyrites (Der Massigen Gesteine, 2 Ed., 1887, vol. ii, p. 519).

3. *Gehlenite in a Furnace Slag.*

Numerous square prisms of gehlenite occur in furnace slag found near McVille, Armstrong, Penn.; accordingly in the thin section it appears square or oblong rectangular. The isotropic square sections are readily found to be uniaxial and negative. Spherical liquid and rod-like inclusions are numerous. Cleavage lines are not conspicuous. The easy gelatinization of the mineral in hydrochloric acid and its difficult fusibility before the blowpipe readily distinguish it from similar minerals. Although not previously reported as occurring in this country, gehlenite is probably one of the most easily obtained specimens to illustrate the optical properties of quadratic minerals in thin sections and on this account alone is worthy of notice.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Determination of molecular mass by means of vapor pressure.*—As early as 1878, Raoult had observed a relation between the diminution of the vapor pressure of a saline solution, the lowering of its freezing point and the molecular mass of the substance dissolved. The relation between the molecular mass and the depression of the solidifying point was developed in 1886 (*Ann. Chim. Phys.*, VI, viii, 317, July, 1886). He has now investigated the relation between the molecular mass of a substance and the lessening of the vapor pressure of a liquid in which it is dissolved, taking ether as the particular solvent employed. He finds that for substances whose vapor pressures are very low compared with that of the ether, there is a relation expressible by the formula $100\frac{f'}{f}=100-KN$; in which f and f' are the vapor pressures of the ether alone and of the etherial solution respectively, at the temperature of the experiment, N the number of molecules of the substance in 100 molecules of the solution and K a constant depending on the character of the dissolved substance, whose value is not far from unity. Thus for turpentine, aniline and ethyl benzoate it was found to be 0·90, for methyl salicylate 0·82 and for nitrobenzene 0·70. Since these values do not greatly vary, K may be taken as equal to unity for all substances, provided that the solutions be dilute, the value of N not being greater than 15. Where N is less than 3, the relation is more complex, arising probably from the fact that the condition of the substance in solution changes with the degree of concentration. If in the above formula N be replaced by $100-N'$, in which N' represents the number of ether molecules contained in 100 molecules of the solution, the above expression (taking K as unity) becomes $100\frac{f'}{f}=N'$; or, in etherial solutions of moderate concentration, the partial pressure of the ether vapor is proportional to N', the number of ether molecules existing in 100 molecules of the mixture, and is independent of the nature of the dissolved substance. Direct experiment showed the ratio of $f':f$ to be independent of temperature between 0° and 21°. The first expression above given $100\frac{f'}{f}=100-KN$ may be put into the form $\frac{f-f'}{f}=\frac{KN}{100}$. The first member of this equation is called the relative diminution of vapor pressure, for the given solution; and hence the law that for all etherial solutions of the same character, the relative diminution of vapor pressure is proportional to the number of molecules of substance which are dissolved in 100 molecules of the solution. Moreover, since K is

unity for moderately dilute solutions, $\frac{f-f'}{f\,N}=0{\cdot}01$. Therefore if the relative diminution of the vapor pressure be divided by the number of molecules of substance existing in 100 molecules of the solution, a quotient of 0·01 is obtained, whatever be the character of the dissolved substance. If R molecules be dissolved in 100 molecules of ether, $N=\frac{100\times R}{100+R}$; and replacing N in the last equation by its value thus obtained, we have $\frac{f-f'}{f\,R}=\frac{1}{100+R}$. In proportion as R decreases, or the solution becomes more dilute, the ratio $\frac{f-f'}{f\,R}$ tends toward 0·01; reaching it when R=1 apparently. Hence if one molecule of a substance be dissolved in 100 molecules of ether, the vapor pressure of the ether is diminished by a fraction of its original value which is nearly constant and which is sensibly equal to 0·01. If m be the mass of the substance dissolved in 100 grams of ether and M be its molecular mass 74 being the molecular mass of ether, $\frac{N}{100}=\frac{74\times m}{100\times M+74\times m}$; and since as above stated $\frac{N}{100}=\frac{f-f'}{f}$, where K=1, we have for the value of the molecular mass $M=0{\cdot}74\ \frac{f\,m}{f-f'}$. Of course this value is approximate only; but if the boiling point of the dissolved substance is above 140° and not more than 20 grams of it be dissolved in 100 of ether, it is sufficient to enable the molecular mass to be fixed as between multiple values. Thus the molecular mass of turpentine thus determined, is 132; of aniline 87; of ethyl benzoate 159·2: and of benzoic acid 124·6; in place of 136, 93, 150 and 122 the true molecular masses. In general the author regards his cryoscopic or fusing point method as preferable; though in special cases the present method is evidently useful.—*Ann. Chim. Phys.*, VI, xv, 375, November, 1888.

G. F. B.

2. *On a Method of Avoiding "Bumping" in Distillation.*—Markownikoff has suggested the use, in place of platinum wire, charcoal, etc., introduced into solutions to prevent bumping during ebullition, a few thin capillary glass tubes 3 to 10 mm in length sealed at one end. Under these circumstances the boiling goes on quietly, both at the ordinary and at reduced pressures, even when a finely divided precipitate like barium sulphate exists in a saline aqueous solution. Even caustic soda solution may be made to boil quietly in this way. Branner recommends that the tubes be made of different sizes so as to float in different layers of the liquid. For the distillation of concentrated acids he has found this method invaluable.—*J. Ch. Soc. Russe*, 1887, 520: *J. Chem. Soc.*, liv., 1155, Nov. 1888. G. F. B.

3. *On Thiophosphoryl fluoride.*—Thorpe and Rodger have published a preliminary notice of a new gas, thiophosphoryl fluoride, PSF_3. It is obtained by heating phosphorus pentasul-

phide with lead fluoride, preferably in a tube of lead. Bismuth fluoride may also be used but a higher temperature is required for the reaction. The gas has also been prepared by heating a mixture of sulphur, phosphorus and lead fluoride, the last substance being added in excess to moderate the reaction. It may also be produced by heating a mixture of arsenic trifluoride with thiophosphoryl chloride in a sealed tube at 150°. The first method, however, is the best since it is the most convenient and gives a pure product. Thiophosphoryl fluoride is a colorless gas, liquefiable in the Cailletet apparatus. It spontaneously ignites in contact with the air, burning, as it issues from a jet, with a pale yellow-green flame tipped with blue. If a considerable quantity of the gas be exposed to the air, it produces a beautiful blue flash, followed by the yellow-green flame. It is sparingly soluble in water, has no action on mercury, is easily decomposed by heat or by the electric spark, and, heated for some time in a glass tube over mercury, the volume alters, phosphorus and sulphur are deposited on the tube and the resulting gas is silicon tetrafluoride. It is slightly soluble in ether, is insoluble in alcohol and benzene, is completely absorbed by lead peroxide and forms a white solid with ammonia. Heated sodium takes fire in it, burning with a red flame, yielding a residual mass evolving spontaneously inflammable hydrogen phosphide on treatment with water.—*J. Chem. Soc.*, liii, 766, Aug. 1888. G. F. B.

4. *On the Relation between the Absorption-spectra of Organic Compounds and their Chemical Composition.*—Krüss has examined the spectra of various organic compounds with a view of obtaining a relation between the absorption-spectra of these compounds and their chemical composition. Solutions of indigo and anthracene derivatives in chloroform or concentrated sulphuric acid were used, and also solutions of fluorescein derivatives in alcohol or water. The paper gives the wave-length of the spectrum lines of maximum absorption for each of the sixty-four compounds examined. In general, the author finds that the substitution of a methyl, ethyl, methoxyl or carboxyl group, or even of bromine, for hydrogen, moves the absorption lines farther toward the red; the similar substitution of a nitro or amido group producing a displacement toward the violet. In four cases only were exceptions found to this law: dibromamido-indigo and bromalizarin being the exceptions to the former, and tetranitro- and dibromodinitro-fluorescein, both in alcoholic solution, to the latter; the displacements produced by these substances being exactly opposite to that normally produced. In the case of the last two compounds, indeed, the aqueous solutions are normal in their displacements. To some extent also the amount of change which the introduction of any of the above groups into a compound produces in its spectrum, appears to depend upon the nature of the compound itself. If absorption lines be considered as produced by the absorption, by the molecules of a compound, of those ether waves whose period is the same as their own, then the vibration-

frequency of these molecules would be represented by the expression $n = \frac{v}{\lambda}$, in which v is the velocity of light and λ the wave-length of the absorption line. Consequently, whenever λ is increased by the displacement of the line toward the red, n will decrease and *vice versa*. Hence when a methyl, ethyl, methoxyl or carboxyl group, or bromine, is introduced into a molecule in place of hydrogen, its period of vibration increases, while when an amido or nitro group is so introduced, the period diminishes.—*Zeitschr. Physikal. Chem.*, ii, 312–337; J. Chem. Soc. liv, 1141, November, 1888. G. F. B.

5. *On the Absorption-Spectrum of Oxygen.*—Liveing and Dewar have examined the absorption spectrum of oxygen at high pressures. The apparatus consisted of a steel tube, 165 cm. long, fitted with gun-metal ends carrying quartz plates and capable of sustaining a pressure of 260 or more atmospheres. At or near its middle point this tube contained a quartz lens of 46 cm. focal length; so that, when a source of light was placed 10 cm. from one end of the tube, an image of it was formed on the slit of a spectroscope at about the same distance from the other end. On admitting oxygen into the tube until the pressure reached 85 atmospheres, and using an arc-light as the source, the authors observed: (1) a very dark band in the position of A of the sun spectrum, sharply defined on its more refrangible side and divided by a streak of light; (2) a precisely similar but much weaker band in the position of the solar band B; (3) a dark band diffuse on both edges, extending from λ 6360 to λ 6225, its maximum intensity being at λ 6305; (4) a still darker band a little above D, beginning with a diffuse edge at about λ 5810, rapidly coming to maximum intensity at about λ 5785, gradually fading out and disappearing at λ 5675; (5) a faint narrow band in the green at λ 5350; and (6) a strong band in the blue, extending from λ 4795 to λ 4750, and diffuse on both sides. By means of photographs it was shown that the oxygen was quite transparent for violet and ultra-violet rays up to λ 2745, then gradually diminishing until at λ 2664 it was wholly absorbed. Upon increasing the pressure to 140 atmospheres, all the bands were strengthened, but only one new one appeared, a faint one at λ 4470 in the indigo. By using a higher dispersion, none of these bands (which appear to be identical with the terrestrial bands observed by Ångström in the sun spectrum) were resolvable into lines. Subsequently a steel tube 18 meters long was employed, which at 90 atmospheres contained a mass of oxygen about equal to that of a vertical column of the atmosphere of the same section; but the intensity of the bands produced by the compressed gas was far greater than that of the corresponding bands in the solar spectrum with a low sun.—*Phil. Mag.*, V, xxvi, 286, September, 1888. G. F. B.

6. *On the Spectrum of Oxygen at high altitudes.*—Janssen has observed the solar spectrum at the Grands Mulets station on Mt. Blanc at an altitude of 3000 meters and has proved that the

lines and bands of terrestrial origin which it contains, especially those due to oxygen, are absent from sunlight before its entrance into our atmosphere. Experiments showed that at this height the bands of oxygen in the red, yellow and blue disappeared completely, the lines B and *a* became very much weakened and the line A was scarcely visible.—*C. R.*, cvii, 672, October, 1888.

G. F. B.

7. *On the Compressibility of Oxygen, Nitrogen and Hydrogen.*—AMAGAT has subjected oxygen, nitrogen and hydrogen gases to pressures up to 3000 atmospheres. He finds that at 1000 atmospheres the compressibility of gases is no greater than that of liquids and increases similarly with the temperature. Calling the density of water unity, the density of oxygen under a pressure of 3000 atmospheres is 1.1054, that of air is 0·8817 that of nitrogen is 0·8293 and that of hydrogen is 0·0887.—*C. R.*, cvii, 522, September, 1888.

G. F. B.

8. *On the Heat of Vaporization of Volatile Liquids.*—Since very little is known of the heat of vaporization of liquids which boil at temperatures below 0°, CHAPPUIS has undertaken the determination of this constant in the case of methyl chloride boiling at −23·75°, of sulphurous oxide boiling at −10·08°, of carbon dioxide boiling at −78·5°, and of cyanogen boiling at −28·4°. The apparatus consisted of a glass cylindrical reservoir having at top a glass spiral or worm, united above to a larger tube cemented into a steel cylinder the opening in which could be closed by a screw cone. A lateral tube permitted this cylinder to be put in communication with a steel reservoir. The whole weighed about 100 grams. This apparatus is exhausted, the reservoir is attached, and the cylinder is two-thirds filled with the liquid to be examined. It is then placed in an ice-calorimeter of Bunsen and the cylinder and worm surrounded with mercury. On opening the compression tap, the liquid evaporates slowly, the heat of vaporization being taken from the calorimeter. After the experiment is ended the apparatus is again weighed. Knowing the mass of the liquid evaporated, the volume of mercury issuing from the calorimeter and the constants of this instrument, the heat of vaporization may be calculated. The results obtained were as follows: For methyl chloride at 0°, the heat of vaporization is 96·9 calories; for sulphurous oxide 91·7 calories; for carbon dioxide 56·25 calories; and for cyanogen 103·0 calories. If these values are referred to the gaseous volume corresponding to the molecular mass in grams, i. e., 22·32 liters, we obtain 4·86, 5·90, 2·48 and 5·36.—*Ann. Chim. Phys.*, VI, xv, 498, December, 1888.

G. F. B.

9. *On the Combination of Oxygen and Nitrogen in Gaseous Explosions.*—It is well known that when hydrogen, in presence of nitrogen, is exploded with excess of oxygen, the nitrogen is itself to a certain extent oxidized. If the eudiometer contains a seven per cent solution of sodium hydrate, the nitrogen oxide produced is absorbed and the liquid contains nitrite and nitrate. VEITH

has undertaken to determine the quantitative relation of this oxidation by exploding repeatedly a mixture of hydrogen and oxygen in the same portion of air, until the volume had perceptibly diminished. Knowing this volume and the composition of the residual gas, he was able to ascertain that one volume of nitrogen had united with two volumes of oxygen. Nitrogen dioxide, or perhaps first nitrogen monoxide which is more permanent at a high temperature, is therefore formed under these circumstances. The quantity of the former produced is at constant pressure, directly proportional to the quantity of mixed gases burned. The quantity of nitrogen oxidized increases with the pressure up to about 300 millimeters; and above this appears to be constant. —*Ber. Berl. Chem. Ges.*, xxi, 695, November, 1888. G. F. B.

10. *Dissipation of Fog by Electricity.*—SORET places a platinum cup full of water in connection with one pole of an electrical machine. A point above the water is connected with the other pole of the machine. The water is caused to boil by means of a Bunsen burner. When the machine is not excited steam ascends in a regular manner, but when the water is electrified the clouds whirl about until the vapor disappears. The cup is illuminated by an electric light and the experiment is made in a dark room.—*Arch. des Sciences*, April, 1888. J. T.

11. *Magnetization of iron and other magnetic metals in a very strong field.*—The results of recent experiments by Professor J. A. EWING and WILLIAM LOW show that no considerable change takes place in the value of the intensity of magnetism in wrought iron when the magnetic force is varied from 2000 to 20,000 C. G. S. units. Throughout this range of force the intensity of magnetism has a sensibly constant value of about 1700 C. G. S. units which is to be accepted as the saturation value for wrought iron. The following are the probable values of the intensity of magnetism when saturation is reached in the particular metals examined:

Wrought iron	1700
Cast iron	1280
Nickel (with 0·75 per cent of iron)	515
Nickel (with 0·56 per cent of iron)	400
Cobalt (with 1·66 per cent of iron)	1300

Hadfield manganese steel, which is noted for its extraordinary inpermeability to magnetic induction, was found to have a constant permeability of about 1·4 throughout the range of force applied to it, namely from 2000 to nearly 10,000 C. G. S.—*Nature*, Dec. 13, 1888, p. 165. J. T.

12. *Figures produced by electric action on photographic dry plates.*—Mr. J. BROWN illustrates his articles by interesting photographs obtained by passing an electrical discharge immediately over or upon the surface of a sensitive dry plate. He believes that the figures are not due to the brush discharge, that actual disrupture discharge over or in the film is not needed to produce an effect visible on development, but that figures are produced

partly at least by direct electric action on the sensitive film which would be usually understood as a purely photo-chemical cause.—*Phil. Mag.*, Dec., 1888, p. 502. J. T.

13. *Spectrum of Cyanogen and Carbon.*—H. W. VOGEL has examined the spectra of the Bunsen flame, the cyanogen flame, the electric light and the various oxides of carbon with the electric spark, and has photographed with Azalin plates the spectra from the orange to the ultra violet. The spectra were photographed over each other in order to measure coincidences. After a discussion of the various bands and lines observed in the different sources of light, the author concludes that the cyanogen spectrum is identical with that of carbon. It seems to him that carbon can emit two spectra—one which gives the bands to the Bunsen flame and another the group of lines which appear clearly in the spectrum of cyanogen when seen by the aid of the electric arc. The channelled bands of the cyanogen spectrum in the red and yellow can be attributed to a compound. A full and remarkable coincidence of an especially bright indigo colored band with the dark back-ground of the G band of the solar spectrum appears in all the spectra. Vogel therefore attributes the dark back-ground of the G line to carbon in the sun.—*Sitzungsber. d. Berliner Ak.*, 21, 1888. J. T.

14. *Determination of the focal length of a lens for different colors.*—HASSELBERG places the objective upon a suitable bar somewhat more than four times the focal length of the lens and obtains, in two positions, clear images of the spectral lines formed by aid of a collimator and suitable prisms. If E is the length of the bar, ε the difference of both positions of the objective, one has $4f = E - \varepsilon^2/E$ in which the thickness of the lens is neglected. —*Bull. de l'Ac. des Sc. de St. Pet.*, xxxiv, p. 412, 1888. J. T.

15. *Electrodynamic Waves.*—At a late meeting of the Physical Society of Berlin, Helmholtz gave an account of the recent researches of HERTZ on the propagation of electrical waves. Weak induction discharges between small metallic cylinders with rounded ends were employed, and a similar apparatus for the detection of the electrodynamic waves. The action was not propagated more than 2 or 3 meters through space; when it fell on a metallic surface it was reflected, interference phenomena were observed and from these the length of half a wave was found to be 30 centimeters. When a metallic parabolic mirror, 1 meter across its opening, was placed behind the apparatus used to produce the discharge, the action was propagated to a distance of 8 meters; and the action was greatly increased when a second concave mirror was placed behind the receiving apparatus. When a conductor was interposed the action ceased, while non-conductors allowed the waves to pass. By interposing perforated metallic screens, it was found that the waves are propagated in straight lines; the waves passed through a dry wooden partition. Polarization of the waves could be determined in several ways. When the receiver was placed at right angles to the apparatus

producing the waves, no action between them could be detected, the vertically produced waves not being picked up by the horizontally placed receiver. When the two pieces of apparatus were placed parallel to each other, and a wooden cable, with a number of insulated metallic wire rings wrapped round it was placed in the path of the electrodynamic waves, it produced the same effect as does a tourmaline plate on polarized light. When the wires were vertical—that is to say, parallel to the exciting apparatus—the action was not propagated through the cube; but it was, on the other hand, when the wires were horizontal. When the receiver with its mirror was placed horizontally, so that it did not record any action on reaching it, and the wire arrangement described above, was placed in the path of the waves, no change took place in the receiver when the wires on the cube were either vertical or horizontal, but the receiver was affected when the wires were placed at an angle of 45°. The laws of reflection of electrodynamic waves at metallic surfaces were found to be the same as those for the reflection of light at plane mirrors. The refraction of pitch for electric waves was found to be 1·68.—*Nature*, Jan. 17, 1889. J. T.

16. *Resistance of electrolytes.*—Professor J. J. Thomson (Royal Society, Jan. 17, 1889) has examined the screening influence of conducting plates upon alternating currents of great frequency, and has deduced thereby the resistance of electrolytes and of graphite. He shows that the screening effect depends on the conductivity and thickness of the plate and upon the frequency of the alternations. The secondary induced currents are confined to the skin of the plate next to the primary, the thickness of this skin varying with the conductivity of the plate and the frequency of the currents. Thus a thin plate of badly conducting material will be efficient with currents of great frequency such as those of the rate 10·8 per second while a thick plate of the best conducting material will not be sufficient to screen off currents of low frequency such as those with a rate below 10·2 per second. Thus to measure the resistance of electrolytes it is necessary to have vibrating electrical systems such as those examined by Hertz, whose frequency is of the former class; and if two different plates produce the same screening effect, their thickness must be proportional to their specific resistances. He supports Maxwell's theory that the rate of propagation of electrostatic potential is practically infinite, a point called in question by Hertz, and he agrees with Hertz that the rate of propagation of electrodynamic action is finite and measurable. He shows that the rate of propagation of an electromagnetic disturbance through a metallic conductor and through the surrounding dielectric is the same, and this differs from one of Hertz's conclusions. But he also shows that this is not so when the conductor is a dilute electrolyte or a rarefied gas. In such cases there would be interferences and standing vibrations. Hence the striæ in so-called vacuum tubes. He also concludes that the relative resistance of electrolytes is the same when the

current is reversed a hundred million times a second as for steady currents."—*Nature*, Jan. 24, 1889. J. T.

17. *Orthochromatic Photography.*—H. W. VOGEL criticises Abney's method of sensitizing a plate, which consists in flowing the dry plate with a colored collodion, and claims that it does not produce the same effect as the direct mixture of the coloring matter with the gelatine layer of the dry plate. The collodion film prevents the molecular action of the sensitizing substance upon the bromide of silver molecules.—*Photog. Mittheil.*, xxv, p. 117–119, 1888. J. T.

18. *Voltaic Balance.*—Mr. G. GORE finds the following apparatus extremely sensitive. An unamalgamated zinc plate and a platinum plate are immersed in a small vessel of distilled water and are connected, through a galvanometer, with a platinum and a zinc plate in another vessel filled with distilled water. The smallest addition of a foreign substance to one or the other vessel causes swing of the galvanometer, and the apparatus can be used to detect extremely small traces of various substances.—*Chem. News*, lviii, p. 64, 1888. J. T.

II. GEOLOGY AND MINERALOGY.

1. *Fossil Plants of the Coal-measures of Rhode Island;* by LEO LESQUEREUX. (Communicated by the author).—The following is a list of the coal plants of Rhode Island, sent for determination by the Museum of Brown University, Providence, R. I., May, 1888.

1. Pecopteris dentata *Brgt.*, 1 a fruiting pinna, Pawtucket.
2. Sphenpoteris (Hymenophyllites) furcata *Brgt.*, Valley Falls.
3. Sphenophyllum oblongifolium *Germ.*, Pawtucket.
4. Dictyopteris Scheuchzeri *Hoffm.?* obscure; nervation obsolete, Pawtucket.
5. Odontopteris Stiehlerian *Goepp.*, fragment, Pawtucket.
6. Odontopteris Reichiana *Goepp.*, separate pinnule, Pawtucket.
7. Odontopteris Reichiana, var. latifolia *Lx.*, Pawtucket.
8. Odontopteris Neuropteroides *Roem.*, Pawtucket.
9. Neuropteris decipiens *Lx.*, Valley Falls.
10. Goniopteris (Pecopteris) unita *Brgt.*, Valley Falls.
11. Pecopteris lepidorachis *Brgt.*, Valley Falls.
12. Asterophyllites equisetiformis *Brgt.*, Pawtucket.
13. Pecopteris Miltoni *Brgt.*, Pawtucket.
14. Schizopteris (Rhacophyllum) trichomanoides *Goepp.*, Pawtucket.
15. Oligocarpia Gutbieri *Goepp.*, Pawtucket.
16. Sphenopteris lanceolata *Gutb.*, Pawtucket.
17. Odontopteris Bairdii *Brgt.*, Pawtucket.
18. Pecopteris hemiteloides *Brgt.?* fruiting pinna, obscure, Pawtucket.
19. Pecopteris Miltoni *Brgt.*, Pawtucket.
20. Pecopteris abbreviata *Brgt.*, fruiting fragment, Pawtucket.
21. Pecopteris arborescens *Brgt.*, fruiting fragments, Pawtucket.
22. Pseudopecopteris dimorpha *Lx.*, fragment of a pinna, Bristol.
22*a* Pseudopecopteris dimorpha *Lx.*, obsolete form, Bristol.
23. Odontopteris cornuta *Lx.*, Pawtucket.
24. Parallel narrow rachises of pinnæ of No. 7, mostly deprived of leaves, Pawtucket.
25. Neuropteris dentata *Lx.* See remarks below, Pawtucket.
26. Odontopteris obtusiloba? *Baum.*

Remarks.—The remains of plants determined above are generally in small fragments more or less deformed, like most of the fossil plants of the Coal-measures of Rhode Island, and therefore their characters are not always satisfactorily recognized. In this lot, they represent mostly species of the Upper Coal-measures, some of which have been recognized in the Lower Permian formations of Europe. Of this kind are Nos. 6 and 7, *Odontopteris Stiehleriana* Goepp., *A. Reichiana* Goepp., *Odontopteris obtusiloba* Baum, etc. This last species has not been recognized before in the Coal-measures of North America, but has been described by Gutbier only from specimens of the Lower Permian, and Geinitz from the Dyas.

No. 25. *Neuropteris dentata* Lesqx., is a very rare species, first described in Rogers's Geol. of Pennsylvania, 1858, p. 859, pl. v, figs. 9 and 10, from four separate pinnules obtained in the Anthracite Coal-measures (the Salem vein of Port Carbon), Pennsylvania the highest coal of the measures. The specimen from Pawtucket, R. I., is more complete, representing the upper part of a pinna with two pairs of large opposite lanceolate pinnules, irregularly sharply dentate on the border, very oblique, decurring to a narrow rachis, with close flabbellate veins derived from a narrow indistinct midrib and very thin though deeply marked. The nervation like the border teeth of the pinnules, is of the same character as represented upon the figures in the Geology of Pennsylvania, the leaflets merely differing by the narrowed, cordate (not decurrent) base.

June 25, 1888.

2. *History of Volcanic Action during the Tertiary Period in the British Isles;* by Archibald Geikie, LL.D., F.R.S., Director General of the Geological Survey of the United Kingdom. 184 pp. 4to, with maps and cuts. Trans. R. Soc., Edinburgh, vol. xxxv, Part 2.—The contrast between the eastern and western borders of the Atlantic in amount of volcanic action has great geological significance, and hence full and detailed descriptions of the facts from the eastern side, like those here presented by Dr. Geikie, have an importance far beyond that of their local or volcanic interest. The facts with regard to the great basaltic areas, those of Antrim of northern Ireland and those of the islands of Mull and Skye and intermediate islands off the coast of Scotland, are described in detail and mapped; and besides these, the many dikes, or subordinate lines of eruption, over Scotland, Ireland and northern England, far away from the main centres, which make the area of fractures and ejections in the Tertiary, according to the author, over 40,000 square miles in extent. The region of outside dikes, referred to, includes the southern half of Scotland, which is intersected by many east and west as well as northwest dikes; and the northern part of Ireland and England where the courses are mostly northwestward. The eruptions may have begun, Dr. Geikie states, in the Eocene; they continued through the Miocene period probably to its close, and perhaps into the Pliocene.

After full descriptions of the great fields of basalt and the surface and intruded outflows, and an account of the rocks—which, although mainly basic, include trachytic, and related kinds and even granite,—Dr. Geikie discusses the origin and history of the disturbances. In the closing summary he observes that, while denudation may have made extensive removals of the lavas, there is still, in the basalt-plateau of Antrim and the region of the Inner Hebrides to the northward, an accumulation of lava streams in some places to a thickness of 3000 feet; and that the outflows continued until they had filled the hollows of the great valley stretching northward from southern Antrim. The region was then mostly above water-level, as is shown by the leaves, stems, fruits and remains of insects found between the streams. The ejections were mainly of lava, fragmental materials being of small amount. The streams appear to have flowed off almost horizontally, not in Dr. Geikie's opinion from any one center, but rather from many. Reviewing the history he remarks that basic outflows, raising the surface some thousands of feet, were followed by other lavas which solidified as coarsely crystalline doleryte, gabbro, troctolyte and picryte. Later, probably after volcanic action had mainly ceased, a renewal of activity brought up trachytic and felsitic rocks, recalling in some respects the trachytic *puys* of Auvergne, and granophyres and granitic vein-like dikes were made in the felsitic masses or spread out in sheets between the beds below. Still later, basic lavas anew outflowed over the surface. Further, the dikes of pitchstone at Antrim and the region north are probably of yet later origin; for "these vitreous protrusions traverse every other of the volcanic series and do not appear to be cut by any"; and at one locality the Scuir of Eigg, the streams of pitchstone flowed out over the basaltic plateau, after it had been cut through by valleys, making "an impressive memorial" of the Tertiary topography of the place.

The greatness of the volcanic results in Tertiary Britain, and not less in many parts of Europe, give emphasis to the fact, alluded to above, that the *western* border of the Atlantic in the same era from the far north to the West India seas, afford no evidence of volcanic fires. J. D. D.

3. *Geological and Natural History Survey of Minnesota.*—Volume II of the final Report on the Survey of Minnesota, by N. H. Winchell, assisted by Warren Upham, has recently appeared—a large quarto volume of 695 pages, with forty-two plates. The volume contains reports on the geology of thirty nine counties by one or the other of the authors above mentioned. Both have made a careful study of the regions. Mr. Upham's attention, as notices of the annual reports in former volumes of this Journal have shown, has been especially directed to the drift—a very prominent feature over the great State, having special interest from the relations of the State in position and

geological history to the Winnipeg region, and the various fortunes of the Mississippi, Minnesota and Red rivers; and through his descriptions Mr. Upham shows that he has well mastered his subject. His reports also cover the stratigraphical geology of many of the counties.

The reports by Prof. Winchell bear especially on the Lower Paleozoic and Upper Mesozoic formations; but also on the drift, the drainage, the topography and the economical resources of the State. A highly interesting part relates to the history of the Falls of St. Anthony, in Hennepin Co., which is illustrated by a number of beautiful views and copies of former pictures. The geology of each county is also presented on a finely colored geological map, adding much to the value of the volume. The State is to be congratulated on the successful results of the survey, and the high character of the Reports.

4. *Geological Survey of Kentucky*, JOHN R. PROCTER, Director.—In the survey of Kentucky under Mr. Procter, several County Reports have been recently issued: on Mason, Bath, Fleming, Henry, Shelby and Oldham Cos., in 1885 to 1887 by W. M. Linney; on Elliott Co., by Prof. A. R. Crandall, in 1887, with notes on the Trap dikes by A. R. Crandall and J. S. Diller (see Mr. Diller's paper in this Journ., xxxii, 121, 1886); on the Jackson Purchase Region, or the seven counties lying between the Tennessee River and the Mississippi, by R. H. Loughridge, 357 pp. 8vo, 1888; and a Chemical Report, by Dr. Robert Peter, containing very many analyses of the coals, soils, clays, petroleum, mineral waters, etc., 171 pp. 8vo, 1888. Besides colored geological maps of some of the counties in the Reports, a small but handsome State geological map was issued in 1887, by J. B. Hoeing, who is at the head of the Topographical Survey. The Reports treat of the Paleozoic rocks, and chiefly of the coal formation of Kentucky; but also of the soils and other points of economical importance. Mr. Procter's Report of Progress of 1887, states that in addition to the coal beneath the Conglomerate, at the base of the Coal-measures, there are above it, north of Pine Mt., 1650 feet of Coal-measures, containing nine beds of workable thickness, and between the Pine and Cumberland Mts. a still greater thickness with twelve or more beds. Mr. Loughridge's Report presents evidence from the results of boring a well at Paducah in western Kentucky, on the Ohio, of a fault of 1350 feet. On the Illinois side, the St. Louis limestone of the Subcarboniferous is at the surface, overlying the Keokuk, while on the Kentucky side the Keokuk, as the boring shows, is about 1350 feet below the surface, and the overlying rock is the Chester limestone, or upper division of the Subcarboniferous. The fault probably extends for some distance southeastward along the east side of the Tennessee River near the junction of the Cretaceous beds of Mississippi valley and the Subcarboniferous.

5. *Geology of New Jersey. Final Report of the State Geologist*, Prof. GEORGE H. COOK. Vol. I, 440 pp. 8vo, with a

colored topographical map of the State. Trenton, N. J. 1888.—New Jersey is the first State in the Union that can boast of a completed topographical survey. The admirable atlas of seventeen maps published the past year—the result of the Geodetic Survey by Prof. E. A. Bowser of the U. S. Coast and Geodetic Survey and of the topographical work of Mr. C. C. Vermeule and his assistants—has prepared the way for the final report of the State Geologist, and the volume now issued is the first of the series. This volume is occupied with a physical, geographical and topographical report of the State, and also a report on the magnetic survey, both of them by Mr. Vermeule, and also by an account of the climate by Prof. Smock. The magnetic report is accompanied by a map of isogonic lines; and the volume by a large colored topographical map of the State of New Jersey, printed in nine colors to indicate altitudes, and by a detailed geographical map.

6. *Woodham Artesian Well, on Long Island, two miles east of East New York*, on the line of the Long Island Railroad; communicated by E. LEWIS, Jr., of Brooklyn, N. Y.—The facts afforded by this well have great interest because they give the thickness of the surface gravels, 213 feet, and of the earlier sand and clays and the depth of the gneiss beneath the surface. The locality is 35·6 feet above high tide. The distance to the outcrops of gneiss on the north shore of the island is 3½ miles, showing a steep incline southward of the floor of gneiss. The only fossils found were the pieces of lignite at 387 feet. No trace of greensand was passed through. The section here given is condensed from memoranda presented to the Long Island Historical Society, on the 5th of February last, by Francis H. Luce.

	Feet.
1. Surface deposits, sand and gravels, yellowish brown or rusty, in thick beds, to a depth of	213
2. Sandy clays, clays, varying in color and fineness, in beds, 145 ft., to depth of	358
3. Quicksand, fine, gray, Lignite in middle of beds	417
4. Layers of sandy clay, 16 ft., blue clay, 3 ft.	436
5. Quicksand, very fine, 7 ft., coarse, clayey sand, 13 ft.	456
6. Coarse, angular, nearly white quartz, sand and pebbles, 4 ft.	460
7. Sandy clay, 10 ft.	470
8. Coarse, silicious sand and pebbles, very light color, *very little water-worn*, 50 ft.	520
9. Clayey sand, 3 ft.	523
10. Very fine, tough, light colored clay, 22 ft.	545
11. Coarse, clayey sand, on the bed rock, 11 ft.	556
12. Bed rock of gneiss, penetrated 21 ft.	577

7. *Bowlder-Glaciation.*—In a paper read before the Tyneside Field Club in 1884, Mr. HUGH MILLER draws attention to the glaciation of stones and bowlders *within* the mass of the bowlder clay, producing what he calls pavement bowlders. He observes that in 1852, Hugh Miller, his father, brought into notice certain causeway-like pavements of bowlders near Portobello. The agent appealed to by the father was icebergs. This recent paper states similar facts from near Edinburgh and elsewhere. The views

given of the "bowlder-pavements" at Fillyside, which, have become exposed to view through seashore action, represent the bowlders as lying close together in the bowlder-clay, and having their *upper* surfaces planed off flat and striated in a common direction. "The smaller stones that are fitted in among the others have escaped striation altogether; others rising a little higher have been brushed atop; while others, again, have been planed off as flat and square-edged as a laundry-maid's iron." The author mentions the common occurrence of small stones with striæ that were evidently derived from fluxion movement in the body of the moving bowlder-clay, and of fluxion structure indicated by the arrangement of the stones. The author is led to conclude that in many cases at least the bowlder-clay is built up slowly and under pressure, and that this pressure was that of a slow-moving, heavily-dragging, wide-spreading mass. "To the theory, if it must still be termed a mere theory, of confluent glaciers one turns as to a really competent agent. For the fluxion-structure it accounts at once. It needs only to be assumed that the dragging ice communicated something of its own motion and structure to the clay over which it passed." "The fluxion-structure is the result of movement; the pavement-bowlders are those elements in the materials that, making of themselves inclined slides, could best resist the movement and were striated atop in resisting."

8. *Archæocyathus of Billings.*—This Cambrian genus hitherto regarded as including only fossil sponges, has been shown by Dr. G. J. Hinde to comprise mainly fossil corals. He makes *Archæocyathus Minganensis* a true lithistid sponge, and names the genus *Archæoscyphia*. *Archæocyathus profundus*, Billings's type of the old genus, is retained still as such, but of the family of *corals*, Archæocyathinæ. *A. Atlanticus* is made the type of a new genus, *Spirocyathus*. The family includes the genera *Archæocyathus* of Billings, *Ethmopyyllum* of Meek, *Coscinocyathus*, *Anthromorpha* and *Protopharetea* of Bornholm, together with *Spirocyathus*. Mr. Hinde states also that *Calathium* and *Trichospongia* of Billings are, like *Archæoscyphia*, undoubted siliceous sponges.—*Proc. Geol. Soc. London*, Dec. 19, 1888.

9. *Analyses of waters of the Yellowstone National Park*, by F. A. Gooch and J. E. Whitfield. (Bull. U. S. Geol. Surv., No. 47.)—These careful analyses of the geyser waters,—43 samples in all—have great interest because of the evidence they appear to afford that the silica present in the silicious waters is mostly if not wholly in the state of dissolved silica and not that of an alkaline silicate. In the waters of the Old Faithful Geyser, the silica constituted 26·54 parts of the total material in solution; in the Giantess, 27·62 p. c.; the Beehive, 25·12 p. c.; the Grotto, 18·15 p. c. Of the other ingredients the analyses give 1·43 p. c., 1·75 and less of boric acid in 100 parts of the total solid material; 16·89, 26·67, 27·06, 35·39, 37·00, 39·22, etc. of chlorine; and mostly 15 to 28 p. c. of sodium. The memoir deserves careful study by the geologist.

10. *Elemente der Paläontologie* bearbeitet von Dr. GUSTAV STEINMANN, Ord. Prof. Geol. Min. Univ. Freiburg, i. Br., unter mitwirkung von Dr. L. DÖDERLEIN, Dir. nat-hist. Mus. Strassburg. 1 Hälfte (Bogen 1–21). *Evertebrata, Protozoa, Gastropoda.* 336 pp. 8vo, with 386 woodcuts. Leipzig, 1888. (Wilhelm Engelmann).—This general treatise on Zoological and Botanical Paleontology describes the groups and genera and illustrates them with many figures representing species and details of structure. It also gives tables showing the geological distribution of groups. The figures are well chosen, and beautifully engraved. The work will be found of great value by students in Geology and Paleontology. The second half, treating of the Invertebrates, the Vertebrates and Plants, is promised in the course of the current year.

11. *Die Stämme der Thierreichs* von DR. NEUMAYR, Wirbellose Thiere. Erster Band., 603 pp. with 192 text-figures. Vienna and Prague, 1889. (F. Tempsky).—Dr. Neumayr treats, in his valuable work, of the successional relations of species in the animal kingdom, in illustration of the subject of evolution. He describes the various groups in zoological order, illustrates their structure and forms by figures, and dwells at length on all the zoological and geological facts that have a bearing on the question of derivation. This first volume of 600 pages carries the work to the close of the Molluscoids (Brachiopods).

12. *Fossil Cockroaches.*—S. H. SCUDDER has described seven new species of *Etoblattina,* from the Barren Coal-measures of Richmond, Ohio.—*Proc. B. S. N. H.*, vol. xxiv, 45, Nov., 1888.

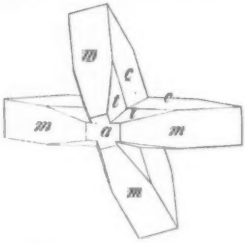
13. *Visual area in the Trilobite, Phacops rana ;* by J. M. CLARKE.—This excellent paper is the result of a thorough study, as far as material allowed, of the composition and structure of the different parts of the eyes in this trilobite, and the relation as regards the eye between the Phacopidæ and other trilobites.—*Journ. Morphol.*, ii, Nov., 1888, Boston.

14. *Mineralogical Notes ;* by E. F. AYRES (communicated). *Thenardite.*—Some specimens of thenardite recently obtained from Borax Lake, San Bernardino Co., California, exhibit a method of twinning that has apparently not been described. The crystals average about an inch in length and are tabular or short prismatic in habit. They show the unit prism, $m(110)$, basal plane $c(001)$, the unit pyramid $o(111)$, and a low macrodome, probably $t(106)$ and probably the pinacoid $a(100)$; the oscillations of the form t give rise to a flat striated surface often replacing c. The crystals are rough and allow only of approximate measurements with a contact goniometer ; these are given here with the angles calculated from the axial ratio of Bärwald.* The position taken is that which makes the prism of nearly 60° vertical.

* Groth's Zeitschr., vi. 36.

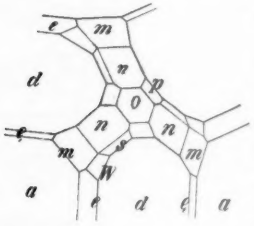
The crystals are for the most part clustered in open loosely coherent groups. They are many of them cruciform twins, crossing at angles of 102° and 78°, which gives as the twinning plane

	Measured.	Calculated.
$110 \wedge \bar{1}10 =$	120°—121°	118° 17′
$110 \wedge 111 =$	21° 40′	22° 17′
$106 \wedge \bar{1}06 =$	40° 32′	38° 31′



the unit brachydome (011, 1-$\bar{i}$) for which we have $001 \wedge 011 =$ 51° 24′. The twins previously described have (101, 1-$\bar{i}$) as the twinning plane. The habit of the crystals is shown in the accompanying figures.

Pyrite.—A group of crystals from Colorado has yielded an unusual combination of forms as represented in part in the accompanying figure. The planes here present are:



$a(100, i\text{-}i)$, $d(110, \text{I})$, $e(210, i\text{-}2)$, $l'(120, -i\text{-}2)$, $o(111, 1)$, $n(211, 2\text{-}2)$, $m(311, 3\text{-}3)$, $p(221, 2)$, $s(321, \frac{3}{2})$, $w(851, 8\text{-}\frac{8}{5})$. The occurrence of both + and − pyritohedrons e and l', is unusual; the measured angles on the cubic plane are 26° 36′ and 53° 35′. Other edges of the same crystal gave a series of reflections corresponding to the following pyritohedrons, viz: 210, 430, 540, 450, 340, 230, 120.

15. *Barite from Aspen, Colorado;* by J. F. Kemp (communicated).—While on a recent visit to Aspen, Colorado, the writer obtained from the Smuggler mines several specimens of beautifully crystallized wine-yellow barite, which closely resemble the variety described by Beckenkamp* from the phonolite of the Kaiserstuhl. The ordinary gangue mineral of the Aspen lead-silver mines is common white barite in foliated masses. The Smuggler mine alone seems to afford crystals. The ore body lies in blue Carboniferous limestone and in this particular mine shows considerable zinc. Cavities in the decomposed ore are found lined with the barite crystals. The largest in my possession are about one-quarter of an inch on a side, but others have been found larger. They are tabular in form showing most prominently 0P and ∞P. Together with these are seen P, $\frac{1}{2}\text{P}\bar{\infty}$, $\text{P}\bar{\infty}$, $\infty\text{P}\bar{\infty}$, $\text{P}\breve{\infty}$, $\infty\text{P}\breve{\infty}$ and a macro-pyramid whose faces, though distinct, are somewhat curved and give measurements which vary several degrees. $mPn \wedge 0\text{P} = 107° - 112°$; $mPn \wedge \frac{1}{2}\text{P}\bar{x} = 153° 50′$ to 156° 40′.

* Groth's Zeitschrift, xiii, 24, 386.

This face is seen only on one side of $\frac{1}{2}P\bar{\infty}$. The angles of the dome and unit pyramid agree within one or two minutes with those tabulated in Dana's System.

Like the Kaiserstuhl variety the crystals are strongly pleochroic; almost colorless parallel with the *b*-axis, deep yellow parallel with the *a*-axis, less intense yellow parallel with the *c*-axis. The crystals are abundantly filled with inclusions of irregular form arranged zonally parallel with the prism faces, making an analysis impracticable. They are doubtless mere dirt or debris brought in by the original barium-bearing solution.

16. *On the serpentine of Montville, N. J.;* by GEORGE P. MERRILL.—A paper recently published in the Proceedings of the U. S. National Museum (pp. 105–111, 1888) gives an interesting description of the New Jersey serpentine, tracing its alteration from the original diopside which is observed in many cases as a nodular nucleus. The following analyses give for one case, the composition of the pyroxene and the resulting serpentine.

	SiO_2	MgO	CaO	Al_2O_3	Fe_2O_3	FeO	Ign.	
Pyroxene	51·45	18·43	24·02	2·94	1·06	0·96	1·08	= 99·94
Serpentine....	40·23	39·46	....	2·18	4·02	*tr.*	14·24	= 100·13

17. *Slipping planes and lamellar twinning in Galena;* by W. CROSS.—It is shown that the cleavage masses of galena from Bellevue, Idaho, are remarkable for the exhibition of lamellar twinning due to pressure. Two kinds of structure are described; in one, bands are seen on a cleavage surface that are parallel to a dodecahedral plane; in another, the laminæ are parallel to different planes but all conform to a common law, the twinning-plane being the octahedron 3.—*Proc. Colorado Sci. Soc.*, vol. ii, part 3.

18. *Some New York Minerals and their localities;* by FRANK L. NASON.—An account is given of fine crystals of brown tourmaline from Newcomb, Essex Co.; pyroxene and associated minerals from Ticonderoga, and calcites from Rossie, the last collected by Professor Emmons.—*Bull. N. Y. State Museum*, No. 4.

III. BOTANY AND ZOOLOGY.

1. *Certain relations of the cell-wall.*—Dr. KOHL (Bot. Centralbl. xxxvii, 1) demonstrates that the growth in thickness of the hairs of many plants is not strictly by intussception nor by apposition, but by periodic depositions of layers of cellulose; and he notes the fact that, between these successive layers, there is generally a trace of protoplasmic matter not easily detected by the use of Millon's reagent. Krabbe has already shown that the growth of bast-fibres is substantially of the same character. G. L. G.

2. *The chemical nature of assimilation.*—TH. BOKORNY (Erlangen, 1888) has conducted some interesting experiments designed to test the truth of the hypothesis of Baeyer, namely, that when sunlight acts on chlorophyll which is surrounded by carbon-dioxide the gas undergoes dissociation as if it were exposed to

a high temperature, and oxygen is eliminated. Further, from this dissociation, carbon monoxide results, and is united to the chlorophyll, where it at once takes up a molecule of water, forming formic aldehyd. In the presence of the free alkalies of the assimilating cells, this primary product can pass at once into the form of sugar. Bokorny has contrived to exclude carbonic acid from the assimilating cells of *Spirogyra*, providing in place of this gas formic aldehyde, methylaldehyde, methyl-alcohol, and, as others had done before him, glycerin. He found that formic aldehyde killed the protoplasm, but he does not regard this as vitiating the hypothesis of Baeyer, since it is possible that this substance is in normal assimilation converted at once into a carbohydrate. With the other substances employed he was moderately successful, and states that from them, even with complete exclusion of carbonic acid, the green cells of a plant can produce starch.

G. L. G.

3. *Improvement in the "races" of the Sugar Beet.*—C. VIOLLETTE and F. DESPREZ (Comptes rendus, 7 Jan., 1889) have carried on a very interesting series of experiments in regard to the Sugar Beet which may be interpreted as indicating that still greater improvement in this useful plant may be reasonably looked for. They state that the manufacturers of sugar have endeavored to use the earlier varieties although the content of sugar is so much smaller, because in this way they have been able to cover a longer time in the manufacture, taking the poor early varieties first, employing some of wretched quality. But the legislation of 1884 compelled the manufacturers to use better varieties, and the only ones at their command were late, coming into maturity during the first fifteen days of October, whereas the earlier ones ripened off at the beginning of September.

The experiments were carried on at Cappelle (Nord) and consisted of careful selection of rich varieties which showed any tendency to hasten maturity. The results are surprising. Whereas the early varieties formerly used contained from 9 to 11·26 per cent. of sugar, the new early varieties or, rather, true *races*, yield from 14 to 16 per cent. Thus the manufacturers have now at their command early races (that is, varieties which come true to seed) which are very rich, and they have also the rich races which mature later, and which furnish from 13·8—16·5 per cent.

G. L. G.

4. *The primordial leaves of Abietineæ.*—DAGUILLON (Comptes Rendus, 14 Jan., 1889) points out the fact that the primordial leaves (that is the leaves intermediate between the cotyledons and the adult leaves) of Abietineæ are pretty constant in form. In some instances, as for example in the genus Pinus, no intermediate steps are to be seen, but in some others various transitional shapes are discernible. The passage from one to the other is characterized by a progressive development of the hypodermis and of the Sclerenchyma adjacent to the fibro-ligneous bundle. In certain cases there is a division of the central nerve into two bundles

under a common Endodermis. The differentiation begins in the internal morphology of the organ. G. L. G.

5. *Notes on Cestoid Entozoa of Marine Fishes;* by EDWIN LINTON.*—This second report on Fish Entozoa, has been handed in for publication.

The paper contains notes on forty-two species of Cestoids, eight of which were described in the first paper.† Only adult forms are described. The following changes in the nomenclature of the first paper have been made.

Phyllobothrium thysanocephalum is referred to a new genus and is recorded under the name *Thysanocephalum crispum*. *Rhynchobothrium tenuicolle* Rud. is referred to a new species *R. bulbifer*. *Rhynchobothrium bisulcatum* is put in Diesing's genus *Tetrarhynchobothrium*. The reasons for these changes are given under the observations on the species. Van Beneden's genus *Acanthobothrium*, which had been combined with the genus *Calliobothrium* by Diesing, is retained. The genus *Echeneibothrium* has been so emended as to exclude those species with echeneiform bothria which are destitute of a myzorhynchus. These are combined in the new genus *Rhinebothrium*.

There are peculiar difficulties in the way of classifying the unarmed *Tetrabothriidæ* and more investigation is needed before the truth is arrived at. Further investigation upon new material may make it possible to unite several genera of the *Phyllobothrinæ*. Several forms were discovered in which the bothria were united into a globe or disc. These have been referred, for convenience, to a common group, to which the family name *Gamobothriidæ* has been given. The genera which have been referred to this group differ greatly from each other but agree in having the bothria united.

One of the most remarkable of the new forms is the one I have named *Paratænia medusia*. This is a small tænia-like worm, which, instead of having a simple papilliform proboscis, or a retractile proboscis armed with hooks, has sixteen flexible tentacular proboscides, which it can either retract, leaving a circular terminal os, or extend, forming a rosette or crown of tentacles like those of an Actinian.

It is to be observed that the species which I have succeeded in identifying with European species belong to hosts which, for the most part, are found on both sides of the Atlantic. The species described in this paper were collected in the months of July and August in the summer of 1886 and 1887 at Wood's Holl, Mass. During the summer of 1887 I made most careful

* Abstract prepared by the author; published with the consent of Marshall McDonald, U. S. Commissioner of Fish and Fisheries. The first paper is incorporated in the Report of the U. S. F. C. for the year 1886. Pp. 453–510. Plates I to VI.

† Lack of space makes it necessary to omit the list of species and the families to which they belong.—EDS.

search for small forms and was eminently successful in my examination of *Trygon centrura* and *Carcharias obscurus*. In the course of these researches a great many encysted forms were obtained. These were most abundant in the Teleostei. The parts most affected were the peritoneum, liver, submucous and muscular coats of the stomach and intestine. Many species of Trematods, Nematods and Acanthocephala were also found. So far as my investigations teach, it appears that very few of the Cestoid entozoa of fish pass their adult stage in specifically different hosts. With regard to the encysted form, however, the range of hosts appears to be greater.

Probably the most interesting result obtained from these researches is the demonstration of a somewhat complicated nervous system in *Rhodobothrium pulvinatum*. This in brief consists of a squarish ganglion in the head at the base of the pedicels connected by paired commissures with smaller ganglia of which there is one in each of the four pedicels. From the latter ganglia smaller branches proceed to the cushion-like bothria. Two lateral branches originate with the principal ganglion, extend back through the neck and presumably continue into the body. Transverse sections made through the head and neck of a *Tetrarhynchobothrium* show that the walls of the contractile bulbs are very thick and are composed of several diagonally interlacing layers of muscles. In these sections the central retractor muscle of the proboscides was seen to be made up of a number of fine longitudinal fibers. What was interpreted as nerves were also seen lying one beside each proboscis sheath and communicating with the anterior ends of the contractile bulbs.

Acknowledgments should here be made to my wife, Margaret B. Linton, for the sketches (XV Plates), which accompany the report and which will doubtless be found to be of more value in establishing the identity of species than the written descriptions.

Washington, Pa., Nov. 9, 1888.

Miscellaneous Scientific Intelligence.

1. *Photographic Map of the Normal Solar Spectrum.*—Physicists will be interested in the announcement that a new and greatly improved edition of the map of the solar spectrum by Professor Rowland, extending from the extreme ultra violet down to and including B to wave-length 6950, is now ready. There are ten plates, lettered from *a* to *j*, each 3×2 feet and containing two strips of the spectrum. Of these ten, all are ready except the first, from wave-length 3350 to the extremity of the spectrum; the work on this may be accomplished this summer and it will be sold as an extra plate. The charge for single plates is $2.50 and for the set of nine (*b* to *j*) $18.00. Subscribers to the old edition will have the preference in the delivery of the new one and a reduction of 10 per cent in the price. The three plates *h*, *i*, *j*, to complete their set, will be furnished for $6.00, or the four, *g*, *h*, *i*, *j* for $8.00.

There are also two plates, each 3×2 feet, suitable for framing of the B and D lines, the latter 3 inches apart and the former having an extent of about 24 inches. Enlargements of some of the carbon bands from the arc electric light have also been made, these bands containing many hundred lines, each one of which is a close double or, in some cases, a triple. These plates will be sold for $2.25 unmounted or $2.50 mounted on cloth.

All subscriptions and orders should be sent and remittances (by draft, or money order) made to the *Publication Agency of the Johns Hopkins University, Baltimore, Md.*

2. *Temperature record at Hilo, Hawaii.*—The following table gives a digest of the thermometric observations made at the United States Consulate Agency at Hilo on Hawaii, by Mr. Charles Furneaux, between April 1 and November 8, 1888. The temperatures are given in the record for each day and from these the means for successive periods of ten days were deduced.

April.	7 a. m.	2 p. m.	7 p. m.	August.	7 a. m.	2 p. m.	7 p. m.
1—10	69	74½	72	1—10	73	80	74
11—20	70	78	71½	11—29	74	81	76
21—30	71	81	75	21—31	73½	81	76
May.				September.			
1—10	70	78	73½	1—10	73	83	76
11—20	72	79	75	11—20	72	82	77½
21—31	74	79	75	21—30	73	82	78
June.				October.			
1—10	73	81	76	1—10	72	82	78
11—20	74	82	76	11—20	72	79½	75
21—30	74	80	76	21—31	71	78	74
July.				November.			
1—10	73	80	76	1— 8	70	78	73
11—20	74	80	76	9—20	71	79½	75
21—31	74	80	76	21—30	71	77	73

December, 1–10, 11–20, 21–31; 69, 77, 72; 68, 76½, 71½; 68, 78, 71.

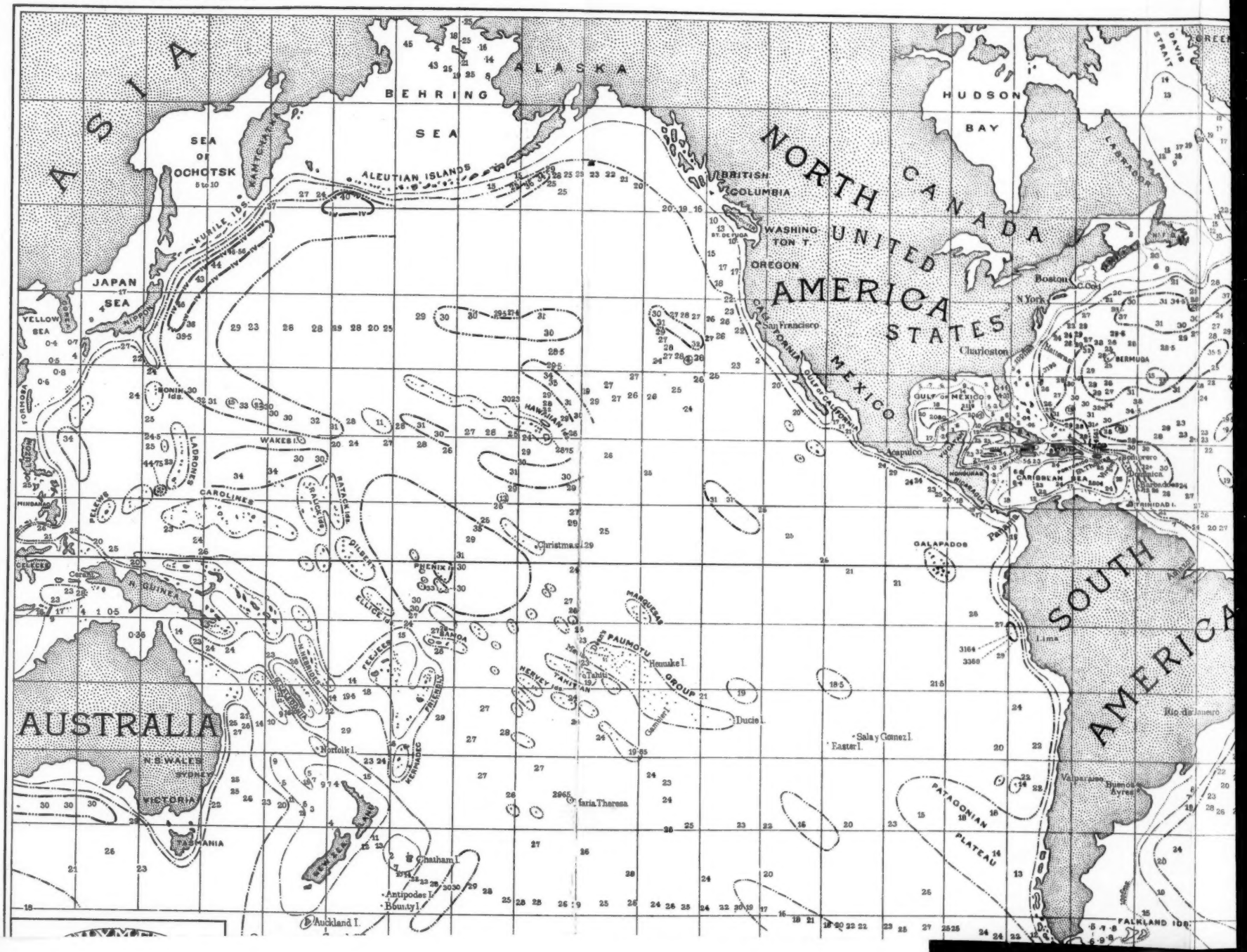
3. *A short Account of the History of Mathematics;* by Walter W. Rouse Ball. 8°, pp. xxxiii, 464, 1888, Macmillan & Co.—Mr. Ball has given us a very readable history and the work is well done. As a general outline history it is a decided advance upon anything we have in the English language. The earlier history especially is well given. There are inherent difficulties when he comes near to the present time, and it is not surprising that Mr. Ball has not entirely overcome them even to his own satisfaction. Something like a defect in perspective is evident in the final chapters. Thus three lines to Grassman and a page to Hamilton will not, we think, be the proportionate space given to the two men in the pages of a history written a century hence. To something like the same cause may be attributed the statements (pp. 413, 414) that Felix Klein is now Professor at Berlin, Otto Hesse Professor at Heidelberg, and that Camille Jordon died in 1878. The persistent misspelling of Bernoulli is so common to other writers as to be easily excused in Mr. Ball's pages. We find only one American name in the book. Among the many excellencies of the book is its admirable index.

4. *The National Geographic Magazine.* Vol. I, No. 1, 98 pp. Washington, 1889.—The "National Geographic Society" was organized in January, 1888, "to increase and diffuse geographic knowledge," and this magazine now appears as the organ of the Society and to aid in the accomplishment of its aims. It is expected that, though issued at irregular intervals at first, the numbers will later appear periodically. The magazine opens most auspiciously in attractive form with a number of valuable papers liberally illustrated. These include the address of the president, Mr. Gardiner G. Hubbard, and also the following: Geographic methods in geologic investigation, by Wm. M. Davis; classification of geographic forms by genesis, by W. J. McGee; the great storm of March 11–14, 1888, by A. W. Greeley and Everett Hayden, with four folded plates; the survey of the coast, by H. G. Ogden; the survey and map of Massachusetts, by Henry Gannett. The proceedings of the Society, by-laws, list of members, etc., close the number. The subjects with which the new Society has to deal are such as will interest and appeal to a large number of persons, and it is to be hoped that it will meet with the hearty support and coöperation which it merits.

Many readers will regret the method too rigidly adhered to of cutting down the adjectives ending in *ical* to a common "*ic*," thus depriving the language in a number of cases of the distinction of meaning which the use of the two independent forms now allows. A *Geologic* society or association is well exemplified in the early Tertiary association of fishes in the Green River basin; a Microscopic society, in the Richmond Infusorial stratum. Magazines may be Microscopical, Geological, Geographical, but not Microscopic, Geologic or Geographic.

5. *Bathymetric Map, Plate VII.*—After the preceding paper was printed, I received a communication from Marshall McDonald, Commissioner of the U. S. Fish Commission, dated February 12, in which he mentioned the very interesting fact that the Albatross, of the Fish Commission, has proved the extension of the deep depression south of the eastern part of the Aleutian Islands to a distance westward of about 400 miles. In crossing it a depth was obtained, in Lat. 52° 20′ N. and Long. 165° 00′ W., of 3820 fathoms. The trough was found to be 30 miles wide. In 52° 18′ N. and 163° 54′ W., the depth found was 2848 fathoms, in 52° 20′ N., 166° 05′ W., 2654 in 52° 40′ N., 166° 35′ W., 2267 fathoms, in 52° 53′ N., 166° 44′ W., 1961 fathoms. The direction obtained for the deep trough was S. 65° W. The conclusion is stated that "The soundings revealed a depression only" and not a continuation of the trough "to the Tuscarora's soundings of 4037 fathoms off Attou." J. D. D.

6. *Soaps and Candles.* Edited by James Cameron, F.I.C. 306 pp. 12mo. Philadelphia, 1888.—This little volume presents in compact form a large amount of information upon a subject of much interest in applied chemistry. It forms one of a series of technological handbooks based upon articles in Cooley's Cyclopedia.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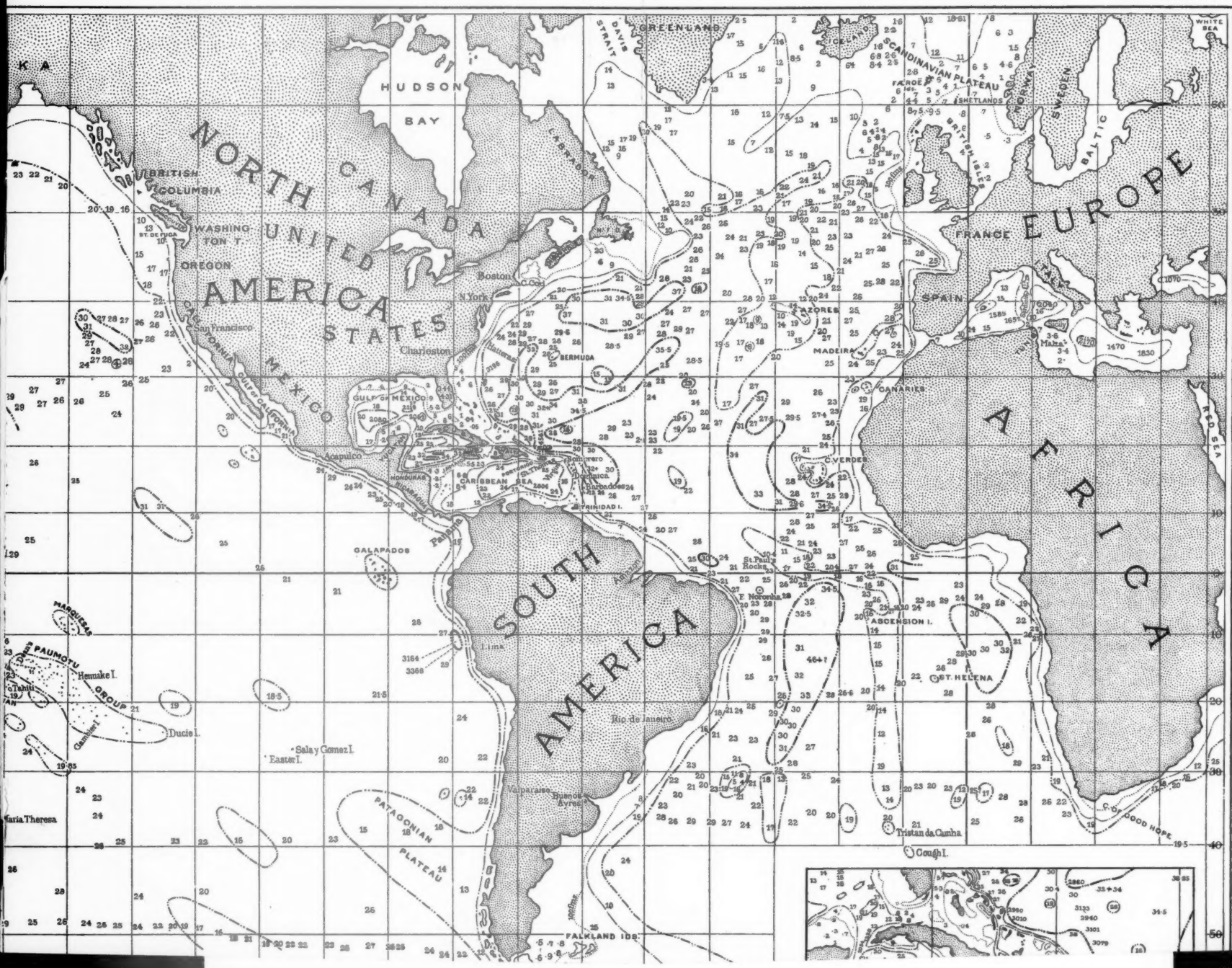
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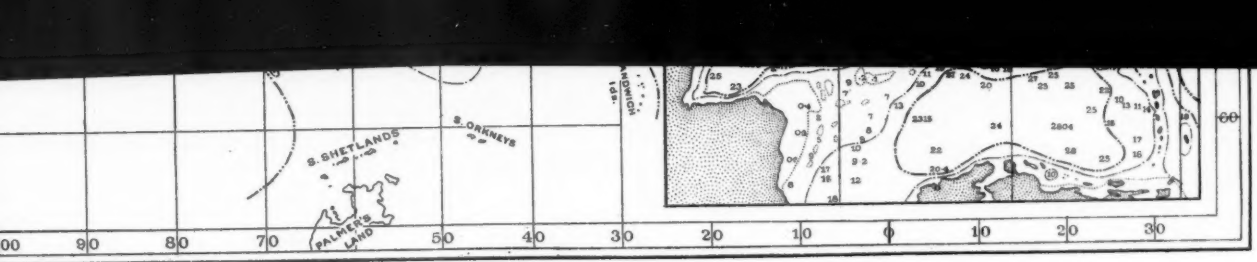
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CONTENTS.

Page.

ART. XIX.—Some Determinations of the Energy of the Light from Incandescent Lamps; by ERNEST MERRITT. 167

XX.—Geology of Fernando de Noronha. Part II; Petrography; by GEORGE H. WILLIAMS. 178

XXI.—Ophiolite of Thurman, Warren Co., N. Y., with remarks on the Eozoon Canadense; by GEO. P. MERRILL 189

XXII.—Origin of the deep troughs of the Oceanic depression: Are any of Volcanic origin? by JAMES D. DANA, with a bathymetric map, Plate VII 192

XXIII.—Description of a problematic organism from the Devonian at the Falls of the Ohio; by F. H. KNOWLTON 202

XXIV.—Some curiously developed pyrite crystals from French Creek, Delaware Co., Pa.; by S. L. PENFIELD 209

XXV.—Crystallized Bertrandite from Stoneham, Me., and Mt. Antero, Colorado; by S. L. PENFIELD 213

XXVI.—Mineralogical Notes; by J. S. DILLER 216

SCIENTIFIC INTELLIGENCE.

Chemistry and Physics.—Determination of molecular mass by means of vapor pressure, RAOULT, 221.—Method of avoiding "Bumping" in Distillation, MARKOWNIKOFF: Thiophosphoryl fluoride, THORPE and RODGER, 222.—Relation between the Absorption-spectra of Organic Compounds and their Chemical Composition, KRÜSS, 223.—Absorption-Spectrum of Oxygen, LIVEING and DEWAR: Spectrum of Oxygen at high altitudes, 224.—Compressibility of Oxygen, Nitrogen and Hydrogen, AMAGAT: Heat of Vaporization of Volatile Liquids, CHAPPUIS: Combination of Oxygen and Nitrogen in Gaseous Explosions, VEITH, 225.—Dissipation of Fog by Electricity, SORET: Magnetization of iron and other magnetic metals, EWING and LOW: Figures produced by electric action on photographic plates, BROWN, 226.—Spectrum of Cyanogen and Carbon, VOGEL: Determination of the focal length of a lens for different colors, HASSELBERG. Electrodynamic Waves, HERTZ, 227.—Resistance of electrolytes, THOMSON, 228.—Orthochromatic Photography, H. W. VOGEL: Voltaic Balance, 229.

Geology and Mineralogy.—Fossil Plants of the Coal-measures of Rhode Island, L. LESQUEREUX, 229.—History of Volcanic Action during the Tertiary Period in the British Isles, A. GEIKIE, 230.—Geological and Natural History Survey of Minnesota, N. H. WINCHELL and W. UPHAM, 231.—Geological Survey of Kentucky, J. R. PROCTER: Geology of New Jersey, G. H. COOK, 232.—Woodham Artesian Well, E. Lewis, Jr.: Bowlder-Glaciation, H. MILLER, 233.—Archæocyathus of Billings, G. J. HINDE: Analyses of waters of the Yellowstone National Park, F. A. GOOCH and J. E. WHITFIELD, 234.—Elemente der Paläontologie, G. STEINMANN and L. DÖDERLEIN: Die Stämme der Thierreichs, NEUMAYR: Fossil Cockroaches, S. H. SCUDDER: Visual area in the Trilobite, Phacops rana, J. M. CLARKE: Mineralogical Notes, E. F. AYRES, 235.—Barite from Aspen, Colorado, J. F. KEMP, 236.—Serpentine of Montville, N. J., G. P. MERRILL: Slipping planes and lamellar twinning in Galena, W. CROSS: New York Minerals and their localities, F. L. NASON, 237.

Botany and Zoology.—Certain relations of the cell-wall, KOHL: Chemical nature of assimilation, T. BOKORNY, 237.—Improvement of the "races" of the Sugar Beet, C. VIOLLETTE and F. DESPREZ: Primordial leaves of Abietineæ, DAGUILLON, 238.—Notes on Cestoid Entozoa of Marine Fishes, E. LINTON, 239.

Miscellaneous Scientific Intelligence.—Photographic Map of the Normal Solar Spectrum, 240.—Temparature record at Hilo, Hawaii; A short Account of the History of Mathematics, W. W. R. BALL, 241.—National Geographic Magazine: Bathymetric Map, Plate VII: Soaps and Candles, J. CAMERON, 242.